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Dynamic Failure of Materials
Volume 2–Compilation of Russian Spall Data

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13. ABSTRACT *(Maximum 200 words)*

Over the past three decades, scientist in the Former Soviet Union (FSU) and in the West have developed innovative experimental techniques, measurement diagnostics, and constitutive models of the Spall Process. Extensive literature has been built up over the years in Western publications. However, much of the FSU work was not available in English and was largely inaccessible to Western readers. Improved communication between Western and FSU scientists since the end of the Cold War now allows the parallel FSU and Western work to be collected, compared, cross-correlated, and examined for new insights and ideas for future directions. The goal of this project was to make formerly inaccessible FSU results available to Western readers and to create a handy reference source for fracture kinetics data, experimental techniques, measurement diagnostics, interpretation methods, constitutive modeling approaches, and numerical computation approaches and results. We hope this work will be useful to investigators and engineers dealing with fast load and fracture as well as to investigators working in the field of physics of strength.

14. SUBJECT TERMS

Spall Fracture	Spall Data	Shock Wave Loading
Spall Experiment	Nucleation and Growth	Numerical Simulation
Dynamic Fracture	Dynamic Fracture Data	Constitutive Modeling

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PREFACE

This project was supported by the Defense Special Weapons Agency (DSWA) and conducted jointly in the High Energy Density Research Center (HEDRC) and in the Institute of Chemical Physics, both of the Russian Academy of Sciences, and in the Poulter Laboratory of SRI International. CDR Kenneth W. Hunter was the DSWA technical monitor.

Special thanks are due to our Russian colleagues at the Institute of Chemical Physics, G. I. Kanel, S. V. Razorenov, and A. V. Utkin, for their very significant contributions to this joint effort. Their work was supported under a separate DSWA contract DNA 001-93-C-0104 under the supervision of Dr. Michael Frankel of DSWA.

This Volume 2 is a compilation of Russian spall data. Volume 1 describes experiments and analyses performed in the United States and the Former Soviet Union.

The initiation of this joint U.S./Russian effort would not have been possible without the active support of Charles W. Martin (then at BMDO and now at ARES Corporation) and Jeffrey Lawrence (then at DSWA and now at Sandia National Laboratory). Thanks are also due to Dr. Michael Frankel of DSWA for solving a number of unglamorous but important administrative problems that arose during the effort.

The Russian portion of the work was performed under the general supervision of academician V. E. Fortov, Director of the High Energy Density Research Center. The SRI portion of the work was performed under the general supervision of Dr. James D. Colton, Laboratory Director, and was based largely on the contributions of two of the present authors, Donald Curran and Lynn Seaman, and on the contributions of T. Barbee, D. Shockey, D. Erlich, R. Crewdson, and many other past SRI researchers to whom the authors express their sincere gratitude. The authors also express their appreciation to Terri Lopez for clerical support and for expert assistance in preparing the manuscript, to Kitta Reeds for editing the manuscript, and to Lee Gerrans for assisting with the illustrations.

CONVERSION TABLE

Conversion factors for U.S. Customary to metric (SI) units of measurement

MULTIPLY → TO GET	BY		← TO GET DIVIDE
angstrom	1.000 000	X E -10	meters (m)
atmosphere (normal)	1.013 25	X E +2	kilo pascal (kPa)
bar	1.000 000	X E +2	kilo pascal (kPa)
barn	1.000 000	X E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350	X E +3	joule (J)
calorie (thermochemical)	4.184 000		joule (J)
cal (thermochemical)/cm^2	4.184 000	X E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000	X E +1	*giga becquerel (GBq)
degree (angle)	1.745 329	X E -2	radian (rad)
degree Fahrenheit	T_K = (T °F+ 459.67)/1.8		degree kelvin (K)
electron volt	1.602 19	X E -19	joule (J)
erg	1.000 000	X E -7	joule (J)
erg/second	1.000 000	X E -7	watt (W)
foot	3.048 000	X E -1	meter (m)
foot-pound-force	1.355 818		joule (J)
gallon (U.S. liquid)	3.785 412	X E -3	meter^3 (m^3)
inch	2.540 000	X E -2	meter (m)
jerk	1.000 000	X E +9	joule (J)
joule/kilogram (J/kg) (radiation dose absorbed)	1.000 000		Gray (Gy)
kilotons	4.183		terajoules
kip (1000 lbf)	4.448 222	X E +3	newton (N)
kip/inch^2 (ksi)	6.894 757	X E +3	kilo pascal (kPa)
ktap	1.000 000	X E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000	X E -6	meter (m)
mil	2.540 000	X E -5	meter (m)
mile (international)	1.609 344	X E +3	meter (m)
ounce	2.834 952	X E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222		newton (N)
pound-force inch	1.129 848	X E -1	newton/meter (N · m)
pound-force/inch	1.751 268	X E +2	newton-meter (N/m)
pound-force/foot^2	4.788 026	X E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757		kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924	X E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011	X E -2	kilogram·meter^2 (kg·m^2)
pound-mass-foot^3	1.601 846	X E +1	kilogram/meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000	X E -2	**Gray (Gy)
roentgen	2.579 760	X E -4	coulomb/kilogram (C/kg)
shake	1.000 000	X E -8	second (s)
slug	1.459 390	X E +1	kilogram (kg)
torr (mm Hg, 0° C)	1.333 22	X E -1	kilo pascal (kPa)

*The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (Gy) is the SI unit of absorbed radiation.

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SECTION 1

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APPENDIX A

WESTERN EQUIVALENTS OF FSU METAL ALLOYS

Material	FSU Alloy Designation	U.S. Alloy Designation	Composition
Aluminum	AD1	1100	
	AMg6M	2017	
	D16	2024	
Magnesium	Ma1	MTA	
Titanium	VT5-1	Ti-5Al-2.5Sn (Alpha phase)	
	VT6	Ti-6Al-4V (Alpha plus beta)	
	VT8	Ti-7Al-4Mo (Alpha plus beta)	
Steel	3 (Low carbon)		C 0.14%-0.22% Mn 0.3%-0.5% Si <0.07% P <0.045% S <0.055%
	45 (Structural carbon steel)		C 0.42%-0.5% Mn 0.5%-0.8% Si 0.17%-0.37% P 0.04% S 0.04% Cr 0.25% Ni 0.25%
	XVG[1] (Doped tool steel)		C 0.9%-1.05% Mn 0.8%-1.1% Si 0.15%-0.35% Cr 0.9%-1.2% W 1.2%-1.6%
	Kh18N10T (High-doped stainless steel of the austenite class)		C <0.12% Mn 1.0%-2.0% Si <0.08% P 0.035% S 0.02% Cr 17%-19% Ni 9%-11% Ti 0.5%-0.7%
	35X3HM[2,3]	–	–
	EP836[4]	–	–

[1]The designation XVG is in Russian letters. The equivalent designation in English letters is KhVG.

[2]The designation 35X3HM is in Russian letters. The equivalent designation in English letters is 35Kh3NM.

[3]The composition of 35Kh3NM steel was not available in the public domain at the time of publication.

[4]The composition of EP836 steel was not available in the public domain at the time of publication.

APPENDIX B

EXPERIMENTAL FSU SPALL DATA

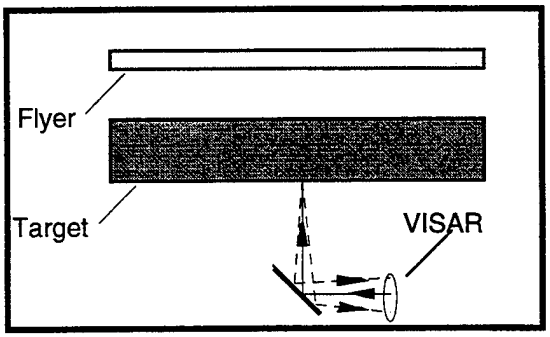
This Appendix contains a compilation of spall experiments performed by Genady Kanel and his co-workers at the Russian Academy of Sciences. It provides a comprehensive, self-contained summary for each of the experiments reported. The information provided includes (1) a description of the material investigated including its density and elastic properties, (2) a schematic of the experiment, (3) the dimensions and conditions of the material investigated, (4) the technique used to perform the measurement and the associated experimental error, and (5) the experimental results, which in all cases take the form of a particle velocity history recorded at the free surface of the sample or at the interface between the sample and a softer material. Table B-1 summarizes the materials included in this compendium and points to the location where data for these materials can be found within this Appendix. The Appendix is organized into 34 sections corresponding to a variety of materials, alloys, and single crystals shock-loaded in different orientations.

Table B-1. Summary of the materials included in this compendium of spall data and the location of the data within Appendix B.

Material	Location of Data	
	Section	Page
Aluminum AD1	B.1	B-3
Aluminum D16	B.2	B-6
Aluminum AMg6M	B.3	B-11
Steel 3	B.4	B-19
Steel 35X3HM	B.5	B-22
Steel 45	B.6	B-31
Steel EP-836	B.7	B-34
Steel Kh18N10T (stainless)	B.8	B-38
Steel XVG	B.9	B-44
Titanium	B.10	B-51
Titanium VT5-1	B.11	B-59
Titanium VT6	B.12	B-63
Titanium VT8	B.13	B-69
Copper M2	B.14	B-73
Copper single crystal	B.15	B-80
Nickel	B.16	B-87
Molybdenum	B.17	B-90
Molybdenum single crystal <100>,	B.18	B-94
Molybdenum single crystal deformed <100>	B.19	B-100
Molybdenum single crystal <110>	B.20	B-104
Molybdenum single crystal <111>	B.21	B-112
Niobium single crystal <100>	B.22	B-118
Niobium, deformed single crystal <100>	B.23	B-122
Magnesium	B.24	B-128
Armco iron	B.25	B-132
Lead	B.26	B-138
Tin	B.27	B-142
Epoxy	B.28	B-145
PMMA	B.29	B-147
Rubber	B.30	B-155
Propellant simulant (filled rubber)	B.31	B-161
Alumina	B.32	B-167
Quartz, x-cut	B.33	B-175
Titanium carbide (with nickel binder)	B.34	B-178

B.1 ALUMINUM AD1.

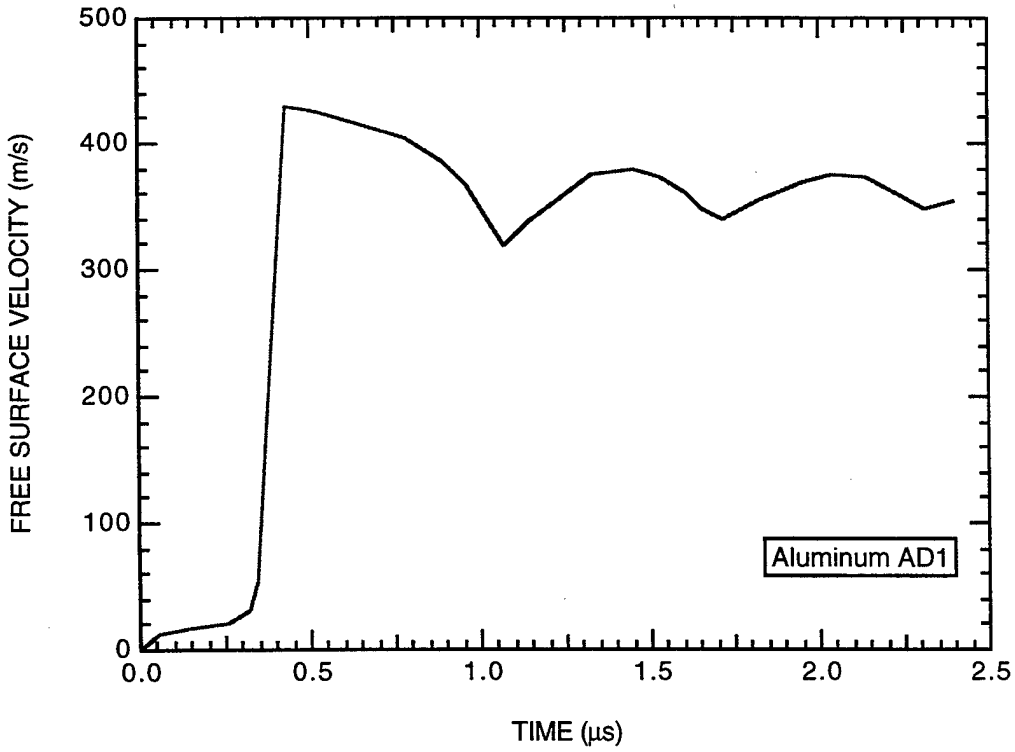
Aluminum AD1	
Density	2.71 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.4 mm/μs



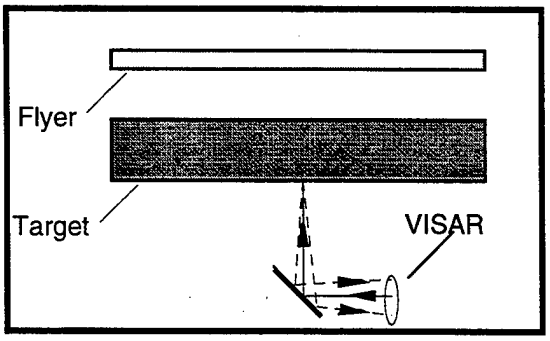
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	AD1 aluminum (rod) 14.9 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.87±0.05 GPa 1.59 mm

Reference: Kanel (1982)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



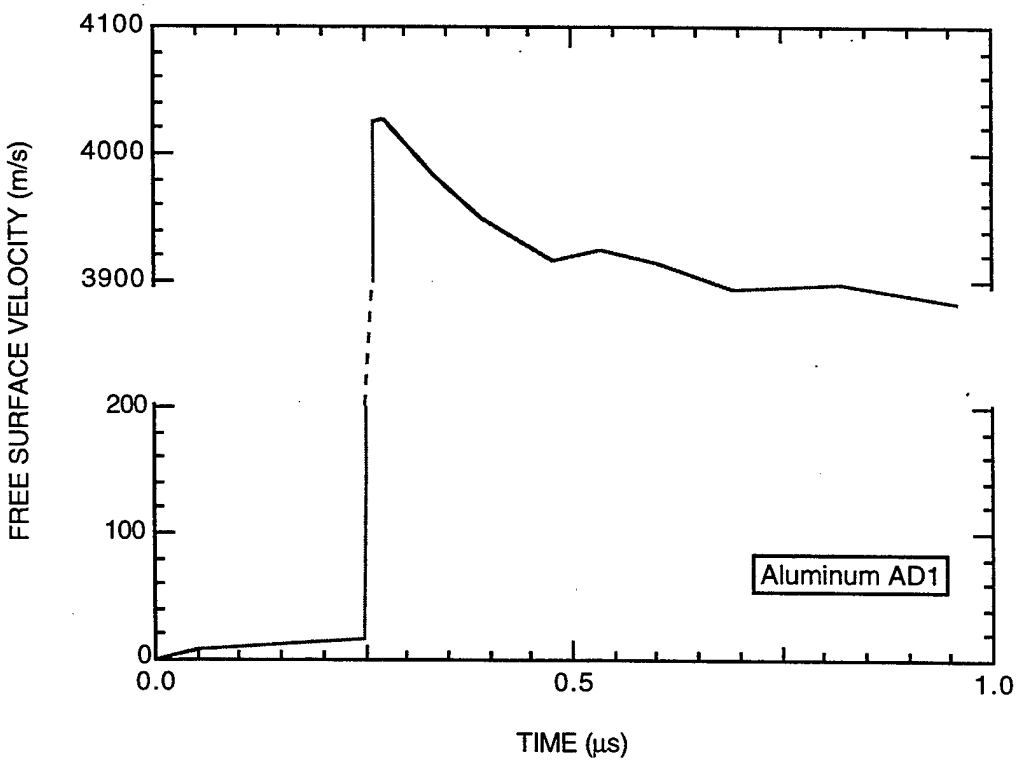
Aluminum AD1	
Density	2.71 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.4 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	4000±150 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	AD1 aluminum (rod) 10 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.87±0.1 GPa 0.68 mm

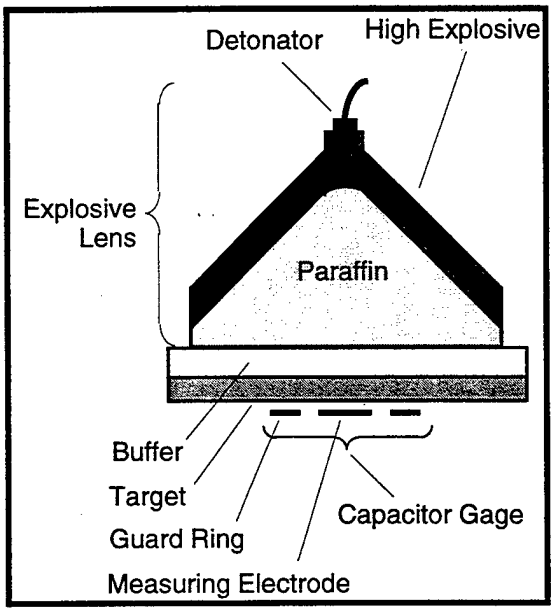
Reference: Kanel (1982)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.2 ALUMINUM D16.

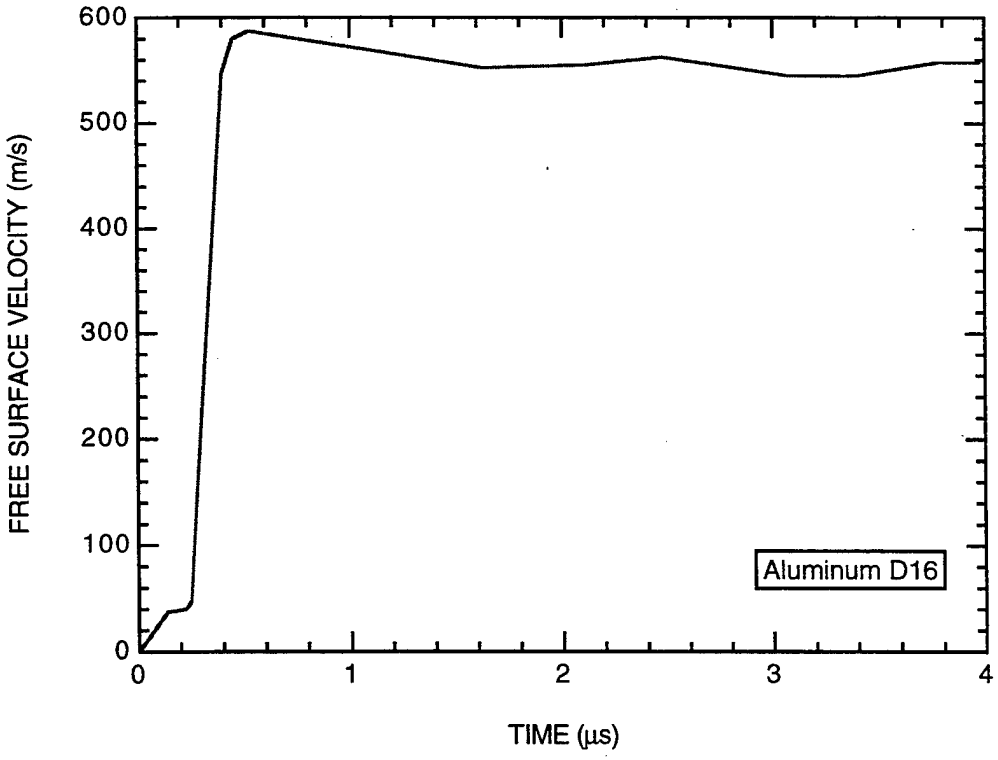
Aluminum D16	
Density	2.78 g/cm^3
Bulk sound velocity	5.34 mm/μs
Longitudinal sound velocity	6.4 mm/μs



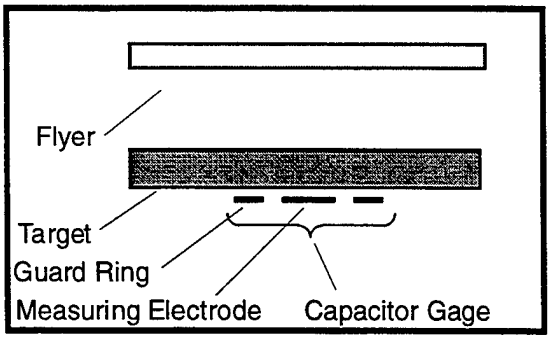
Experiment Summary		
Loading condition Loading method		1-D strain In-contact explosives
Buffer:	- material - thickness	Copper 10 mm
Target:	- material - thickness	D16 aluminum (rod) 10 mm
Measurement technique Electrode diameter		Capacitor gage 20 mm
Measurement accuracy		±4%
Spall strength Spall thickness[1]		0.6±0.05 GPa 4±0.5 mm

Reference: Kanel (1982)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



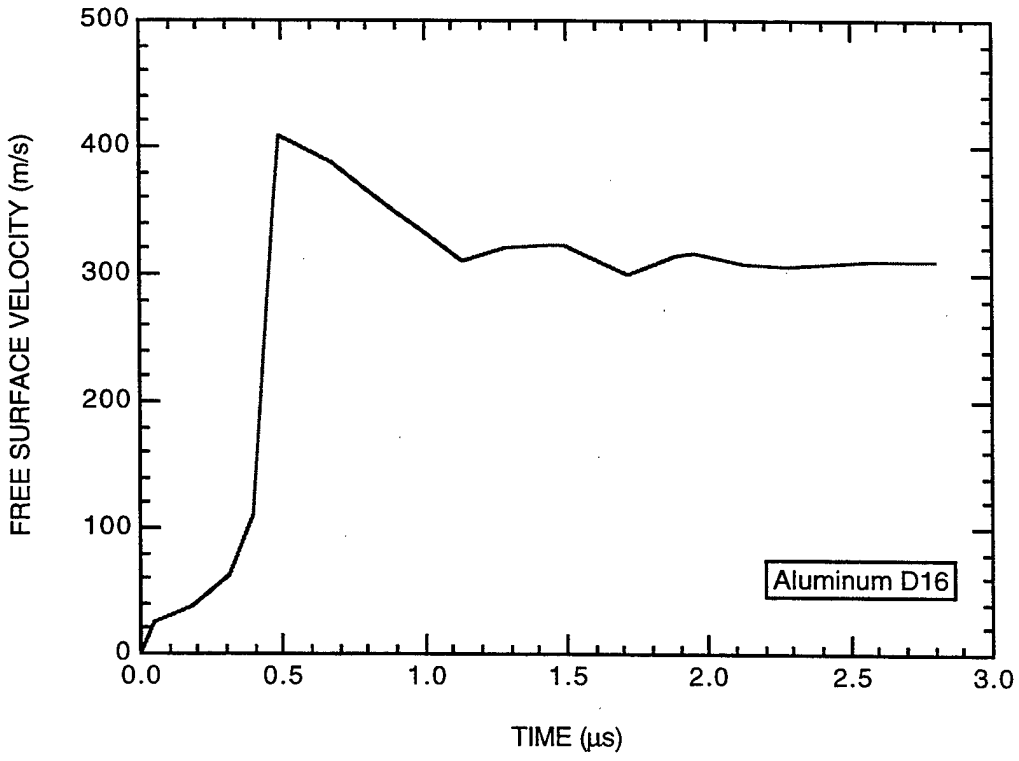
Aluminum D16	
Density	2.78 g/cm^3
Bulk sound velocity	5.34 mm/μs
Longitudinal sound velocity	6.4 mm/μs



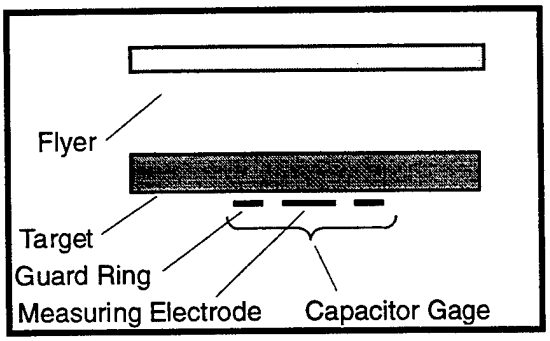
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	D16 aluminum (rod) 15 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.78±0.05 GPa 1.85 mm (±10%)

Reference: Kanel (1982)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



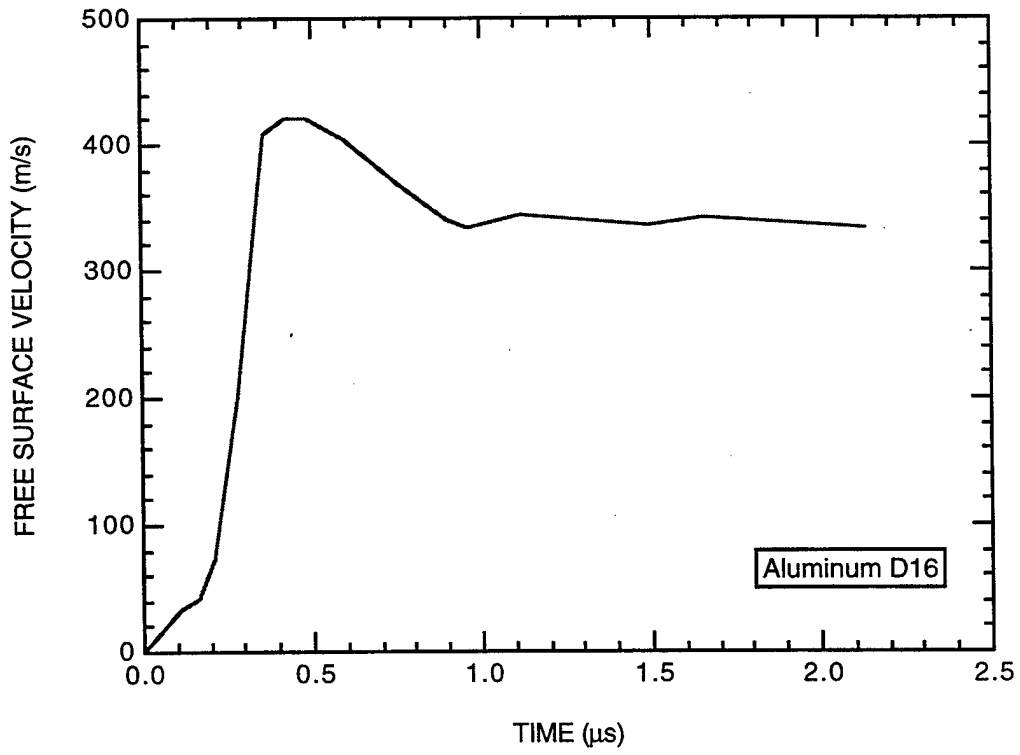
Aluminum D16	
Density	2.78 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.4 mm/μs



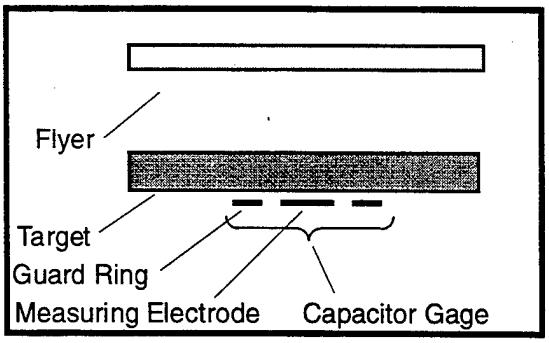
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness - diameter	Aluminum 2 mm 60 mm (plane section)
Target: - material - thickness	D16 aluminum (rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.72±0.05 GPa 1.73 mm (±10%)

Reference: Kanel (1982)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



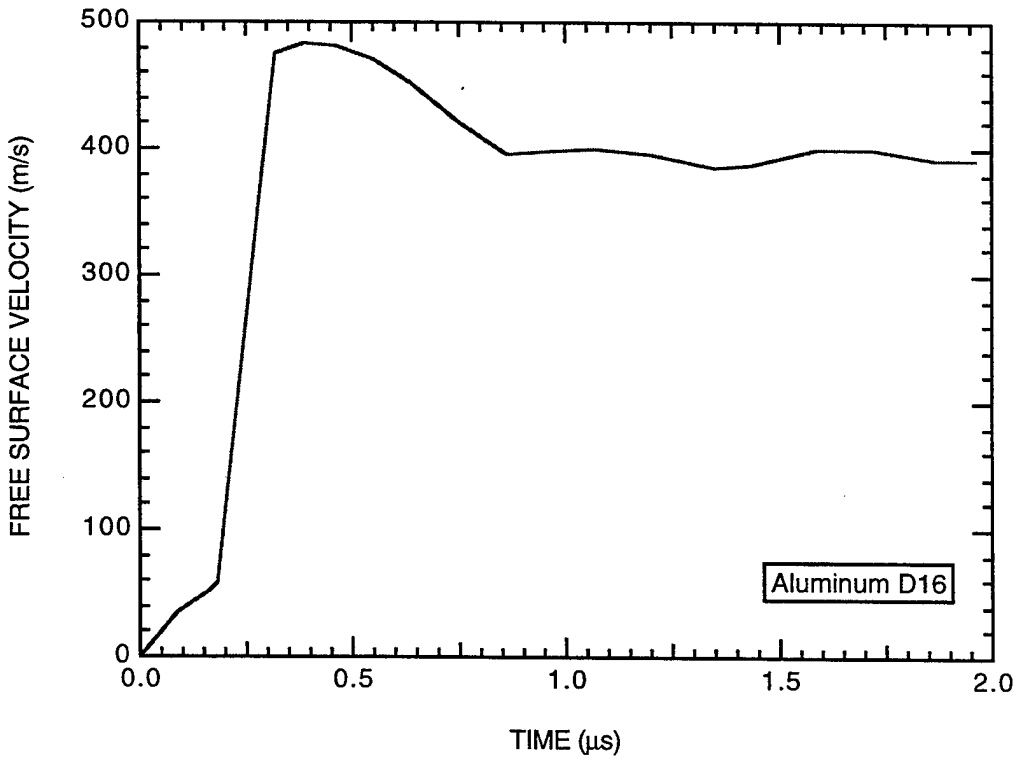
Aluminum D16	
Density	2.78 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.4 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±20 m/s
Flyer plate: - material - thickness - diameter	Aluminum 2 mm 60 mm (plane section)
Target: - material - thickness	D16 aluminum (rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.66±0.05 GPa 1.54 mm (±10%)

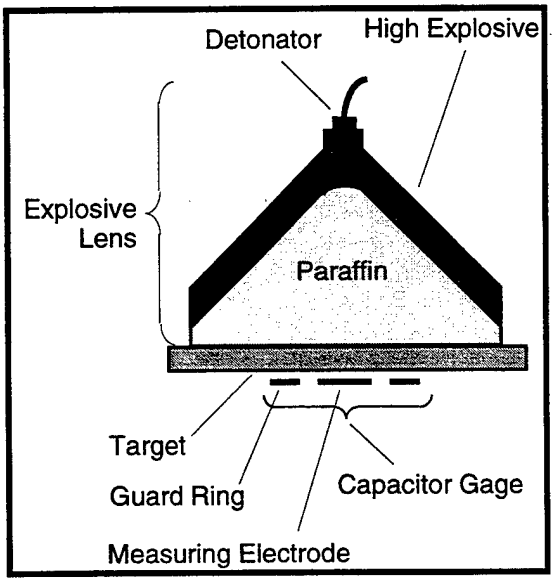
Reference: Kanel (1982)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.3 ALUMINUM AMg6M.

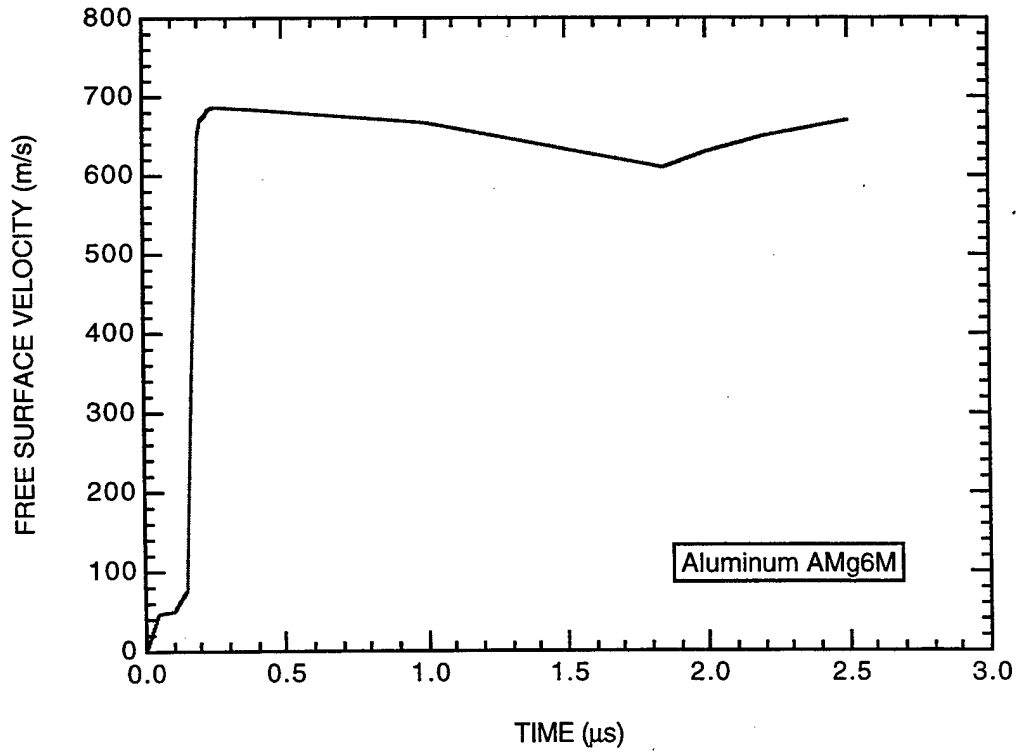
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



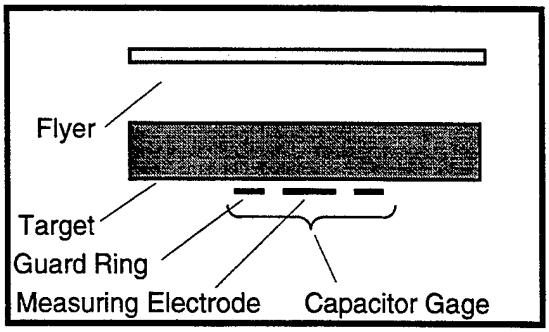
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	AMg6M aluminum (sheet) 10.0 mm
Measurement technique Electrode diameter	Capacitor gage 5 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.57±0.1 GPa 4.7 mm (±10%)

Reference: Kanel et al. (1984)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



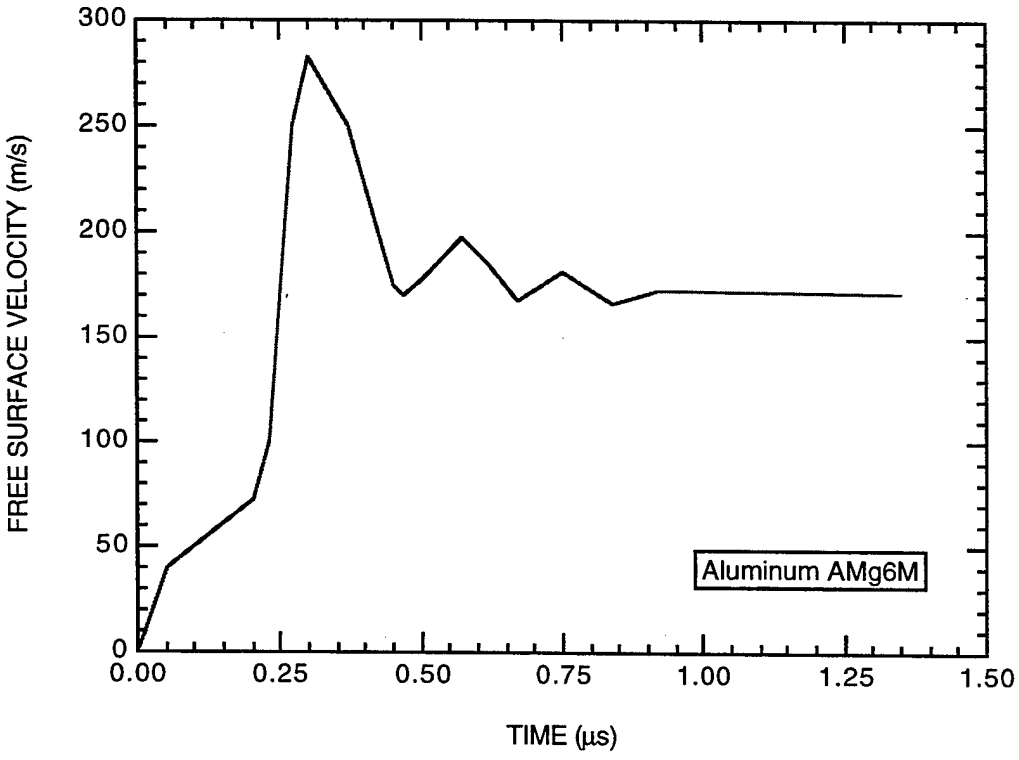
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



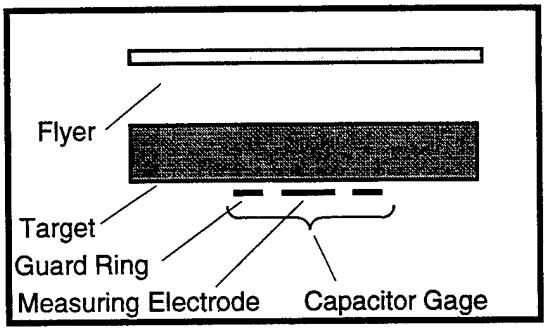
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	AMg6M aluminum (sheet) 9.6 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.83±0.08 GPa 0.61 mm (±10%)

Reference: Kanel et al. (1984)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



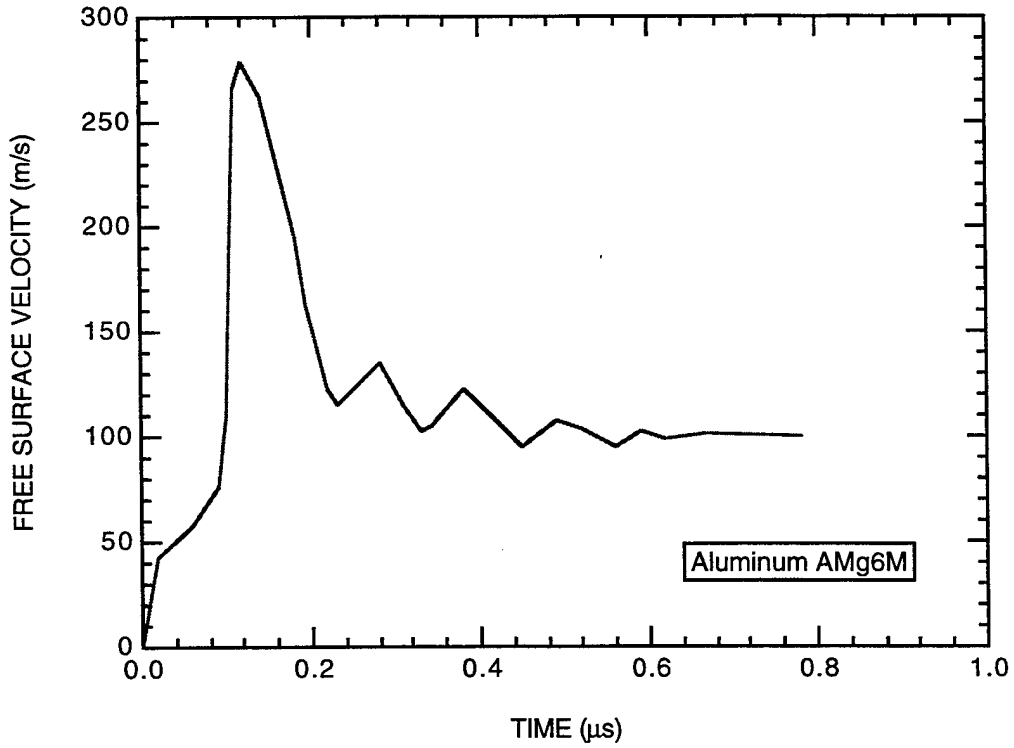
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



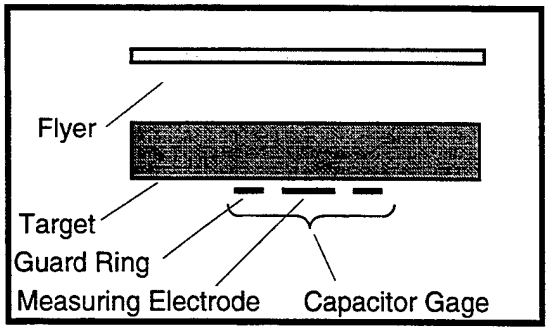
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.19 mm
Target: - material - thickness	AMg6M aluminum (sheet) 4.4 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.15±0.05 GPa 0.34 mm (±10%)

Reference: Kanel et al. (1984)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



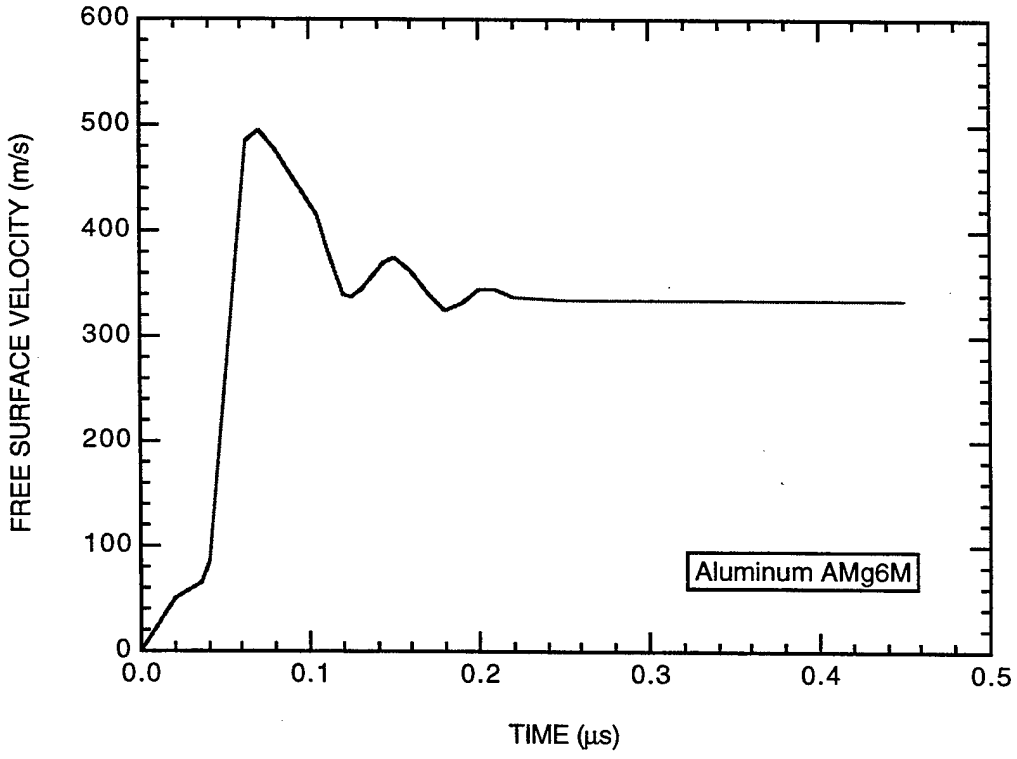
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



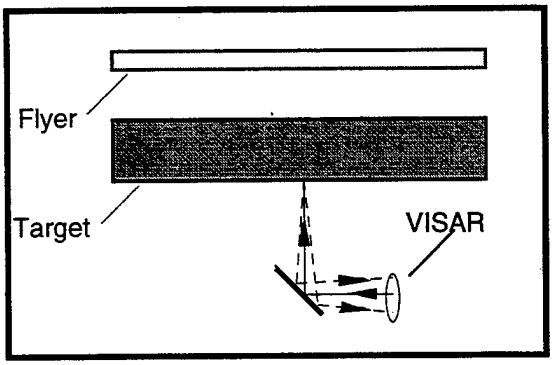
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.19 mm
Target: - material - thickness	AMg6M aluminum (sheet) 1.8 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.2±0.12 GPa 0.18 mm (±10%)

Reference: Kanel et al. (1984)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



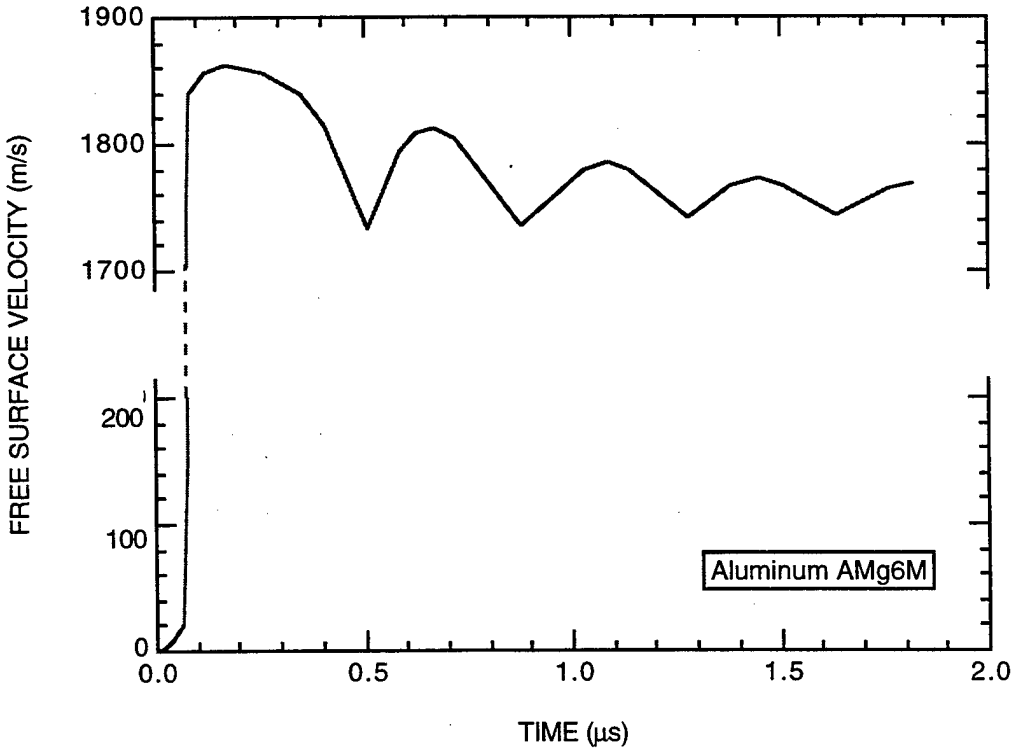
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



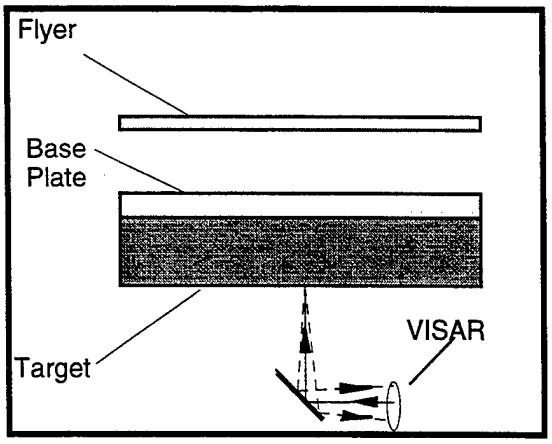
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	AMg6M aluminum (sheet) 7.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.93±0.04 Gpa 1.23 mm (±10%)

Reference: Razorenov and Kanel (1986)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



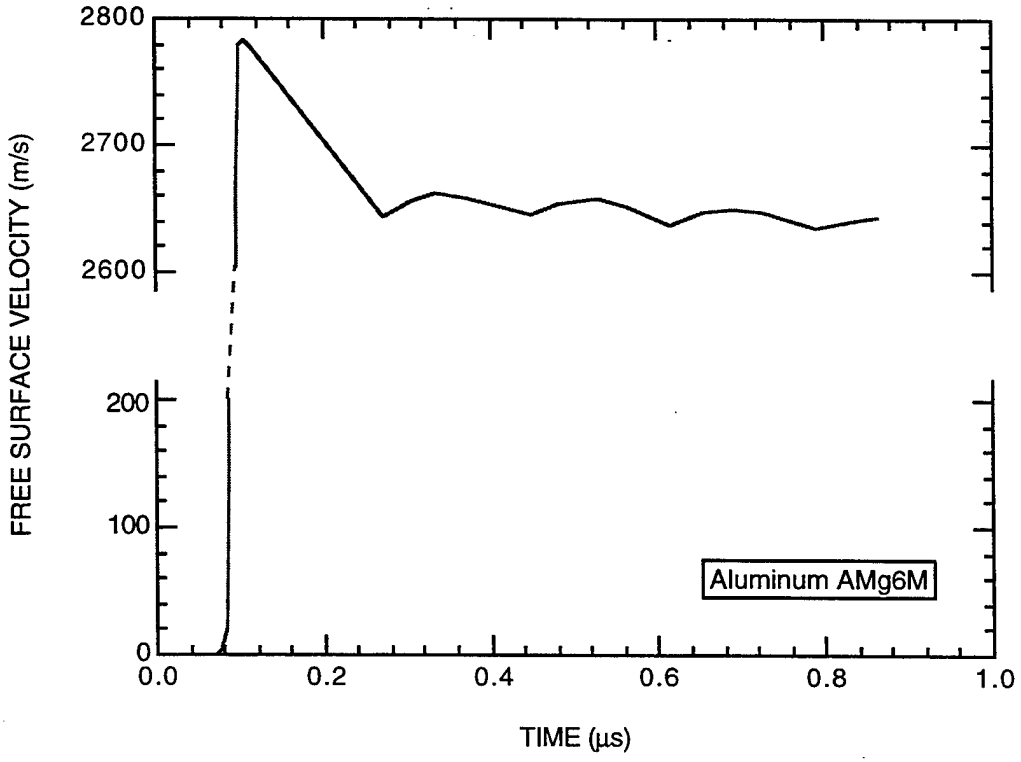
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



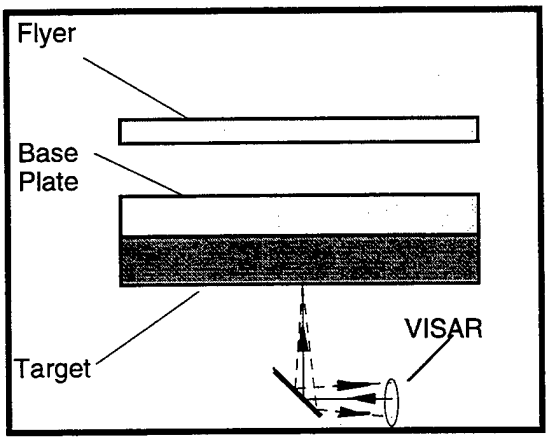
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	3000±100 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Base plate: - material - thickness	Copper 4 mm
Target: - material - thickness	AMg6M aluminum (sheet) 10.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.93±0.04 GPa 0.54 mm (±10%)

Reference: Razorenov and Kanel (1986)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



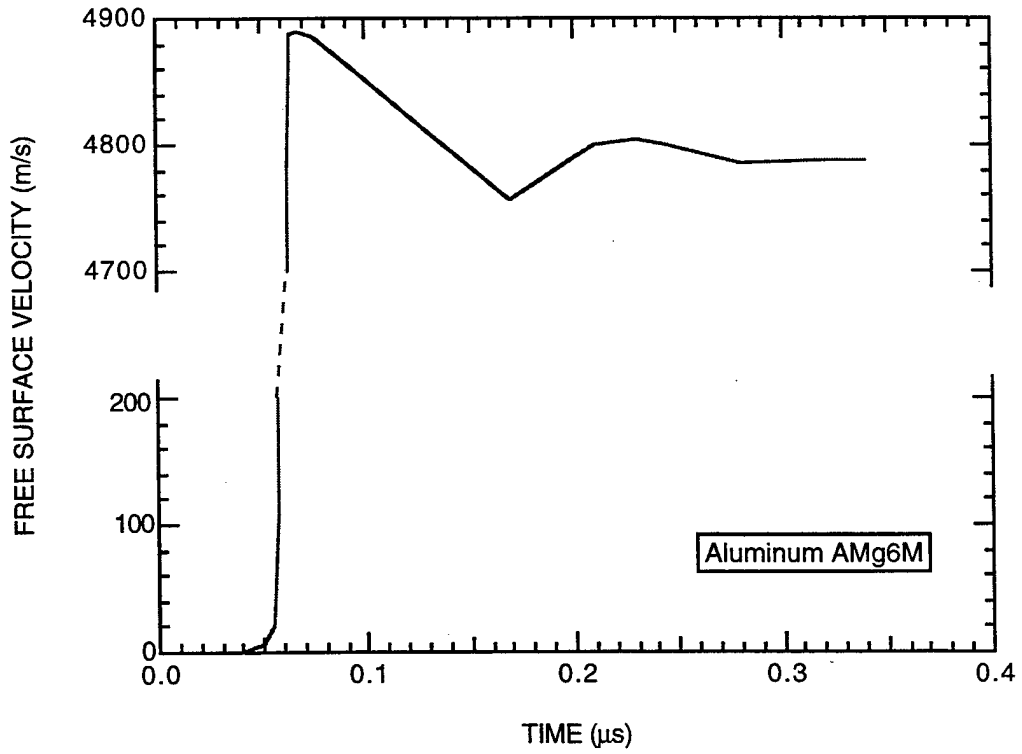
Aluminum (AMg6M)	
Density	2.61 g/cm^3
Bulk sound velocity	5.25 mm/μs
Longitudinal sound velocity	6.40 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	5300±150 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Base plate: - material - thickness	Copper 4 mm
Target: - material - thickness	AMg6M aluminum (sheet) 4.5 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.93±0.04 GPa 0.35 mm (±10%)

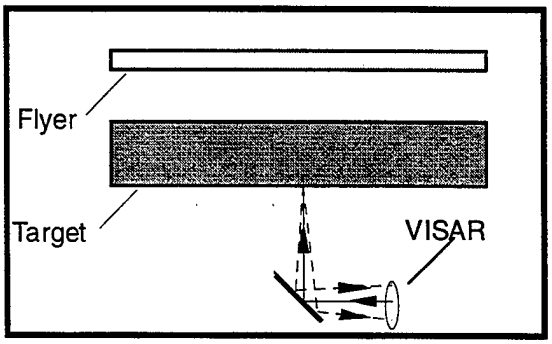
Reference: Razorenov and Kanel (1986)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.4 STEEL 3.

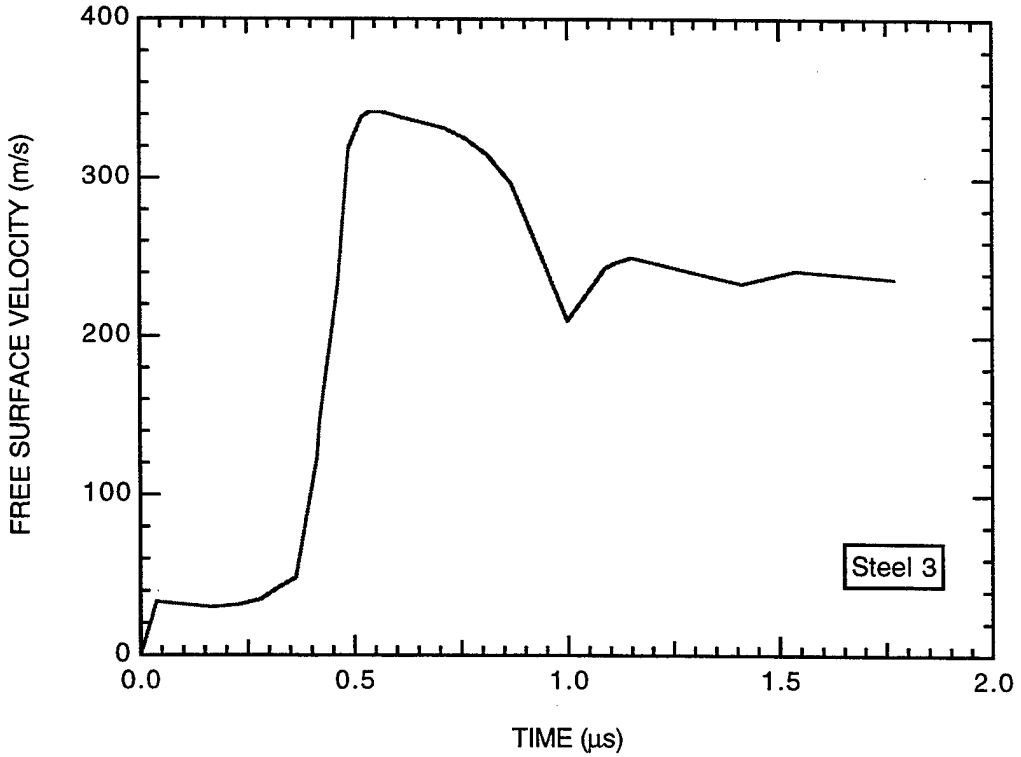
Steel 3	
Density	7.85 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



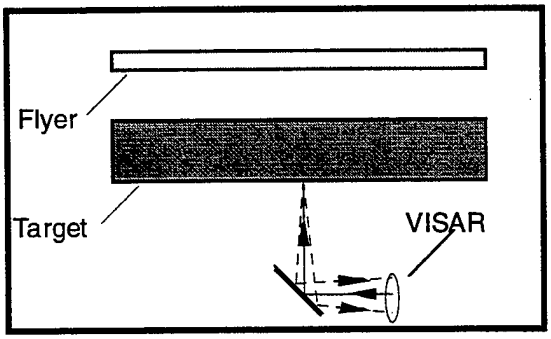
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Steel 3 (rod) 10.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	2.9±0.1 GPa 1.16 mm (±10%)

Reference: Kanel et al. (1987)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



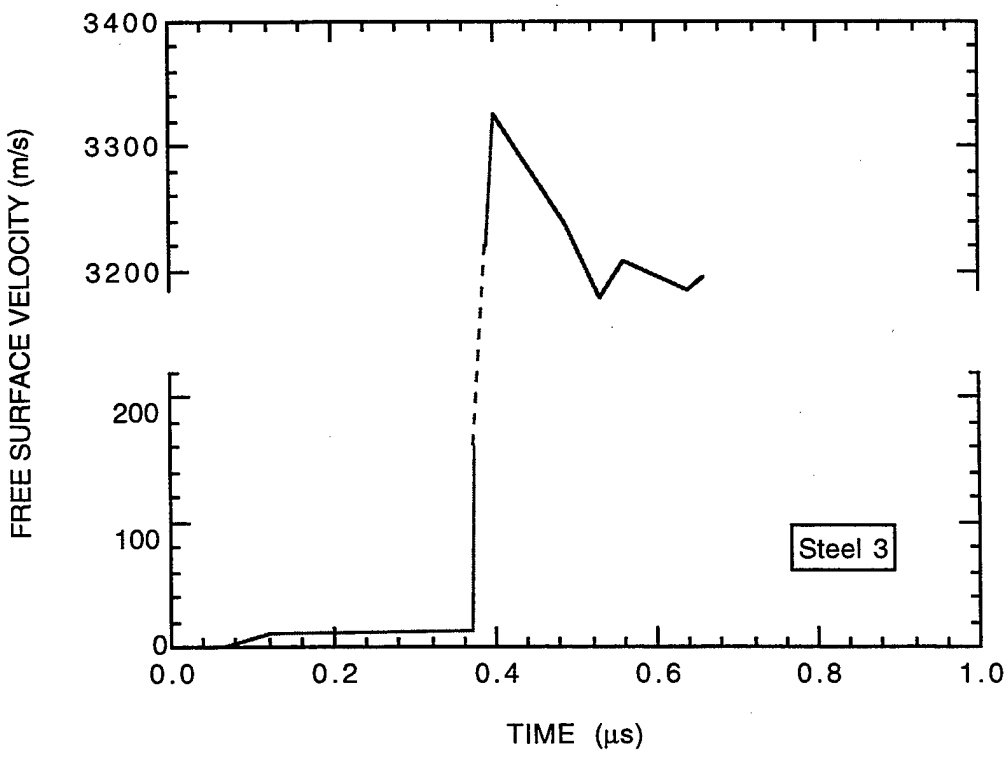
Steel 3	
Density	7.85 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	5300±150 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Steel 3 (rod) 5.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	2.9±0.1 GPa 0.31 mm (±10%)

Reference: Kanel et al. (1987)

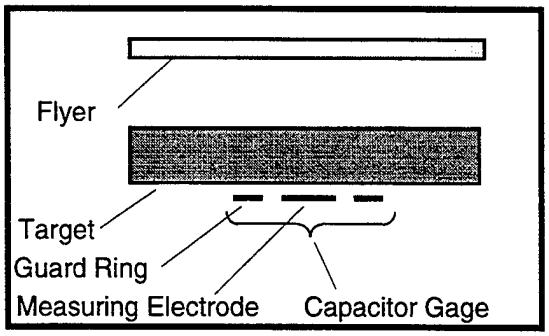
[1] Determined based on the period of oscillation in
[1] Determined based on the period of oscillation in the measured free-surface velocity history.



Note: The precursor in the figure is caused by an air shock wave ahead of the flyer plate.

B.5 STEEL 35X3HM[1].

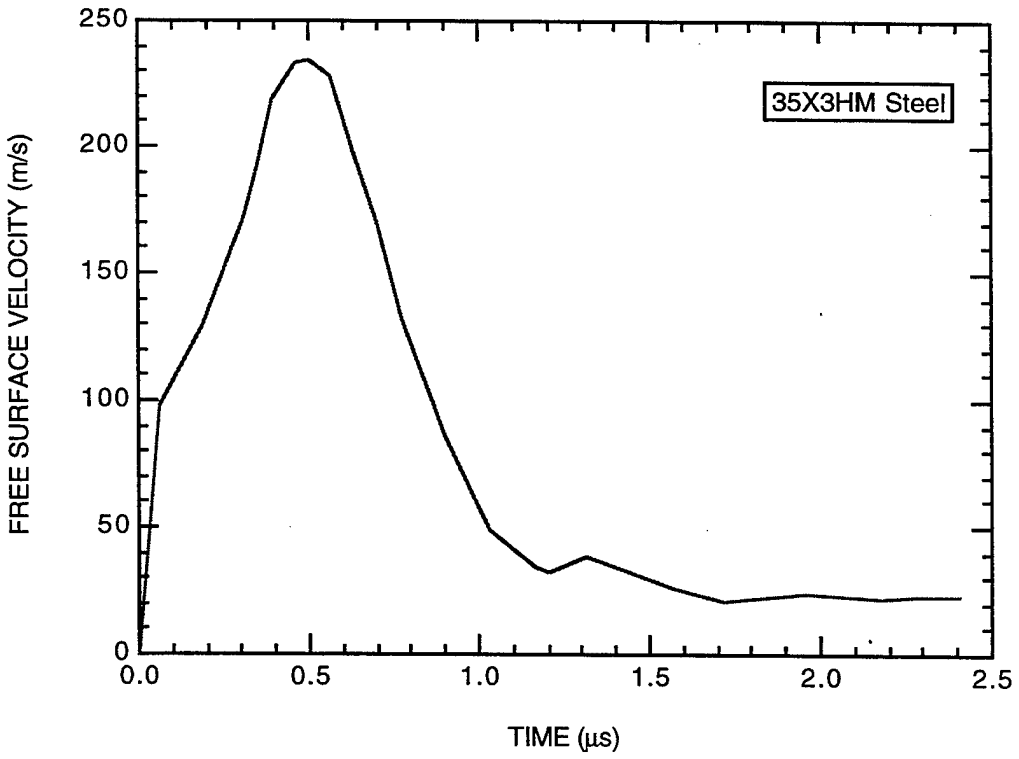
35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	35X3HM steel[1] 10.1 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength	No spall

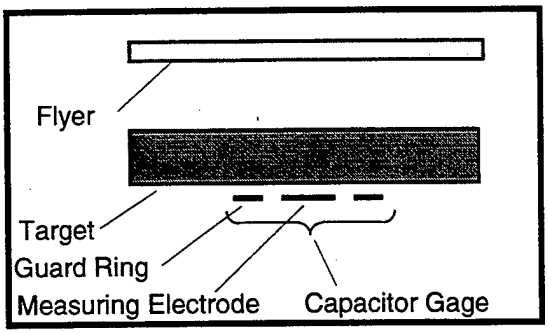
Reference: Gluzman et al. (1985)

[1] Rod - Batch I - loaded in the rolling direction.



[1] The designation 35X3HM is in Russian letters. The equivalent designation in English letters is 35Kh3NM.

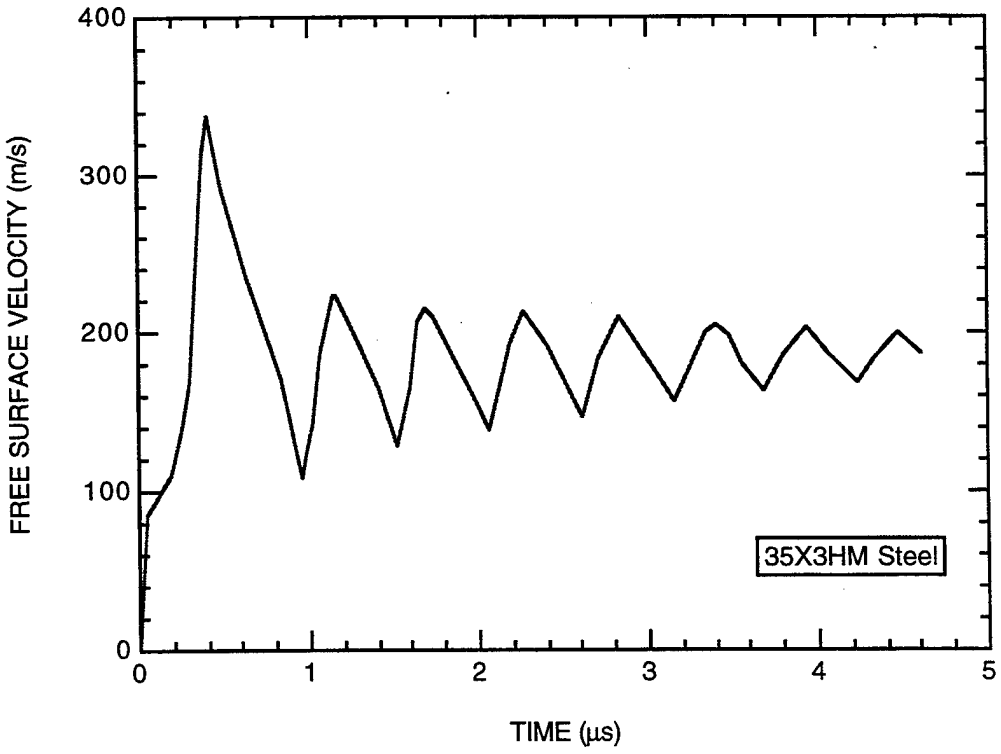
35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs



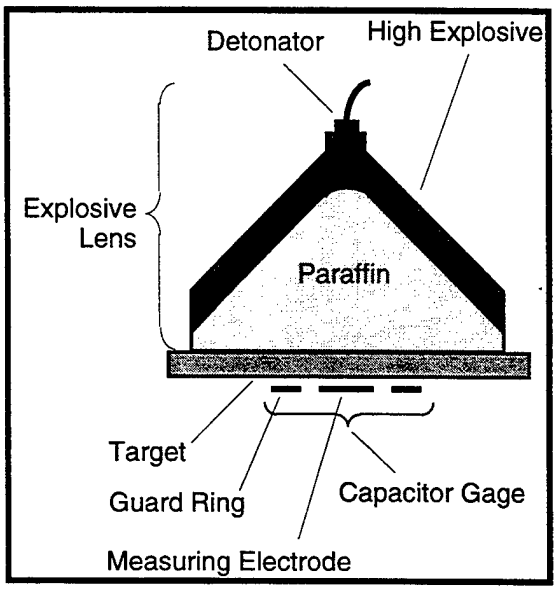
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	35X3HM steel[1] 10.4 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[2]	4.4±0.2 GPa 1.6 mm (±10%)

Reference: Gluzman et al. (1985)

[1] Rod - Batch I - loaded in the rolling direction.
[2] determined based on the period of oscillation in the measured velocity history.



35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs

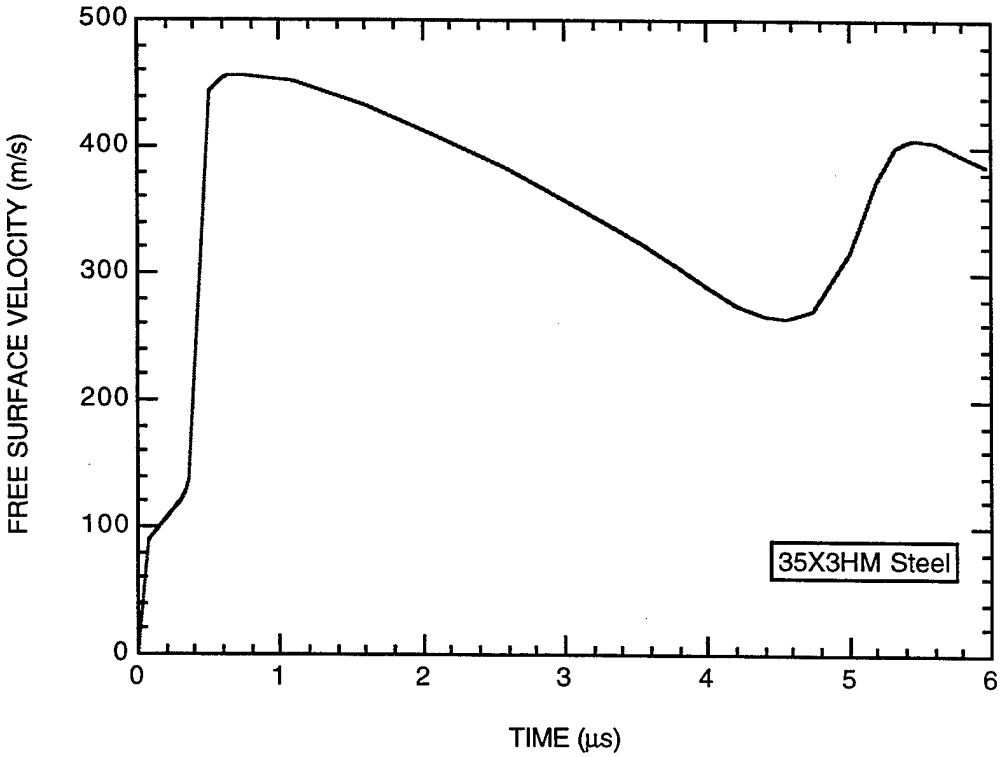


Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	35X3HM steel[1] 15.2 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[2]	4.0±0.2 GPa 9.9 mm (±10%)

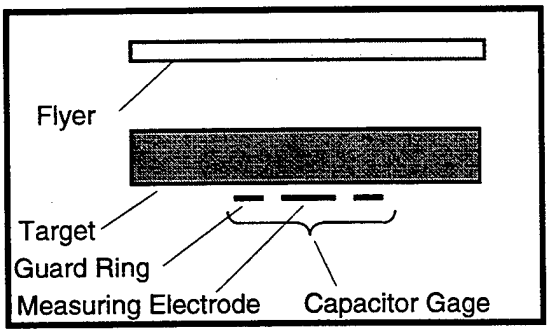
Reference: Gluzman et al. (1985)

[1] Rod - Batch I - loaded in the rolling direction.

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs

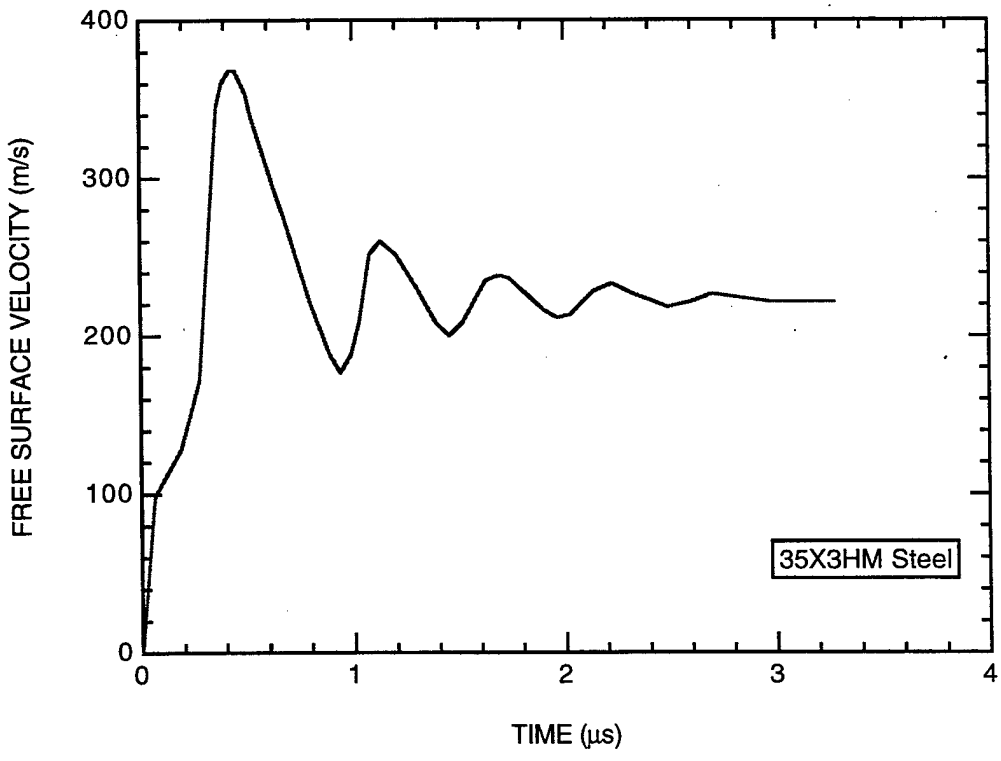


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	35X3HM Steel[1] 9.8 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[2]	3.85±0.1 GPa 1.5 mm (±10%)

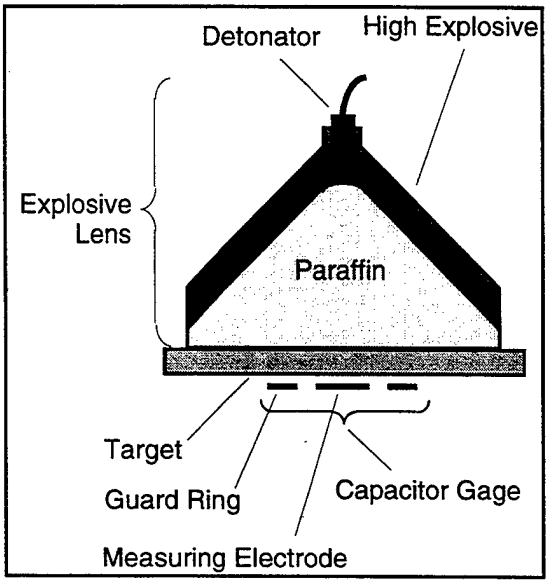
Reference: Gluzman et al. (1985)

[1] Rod - Batch I - loaded in the lateral direction.

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs

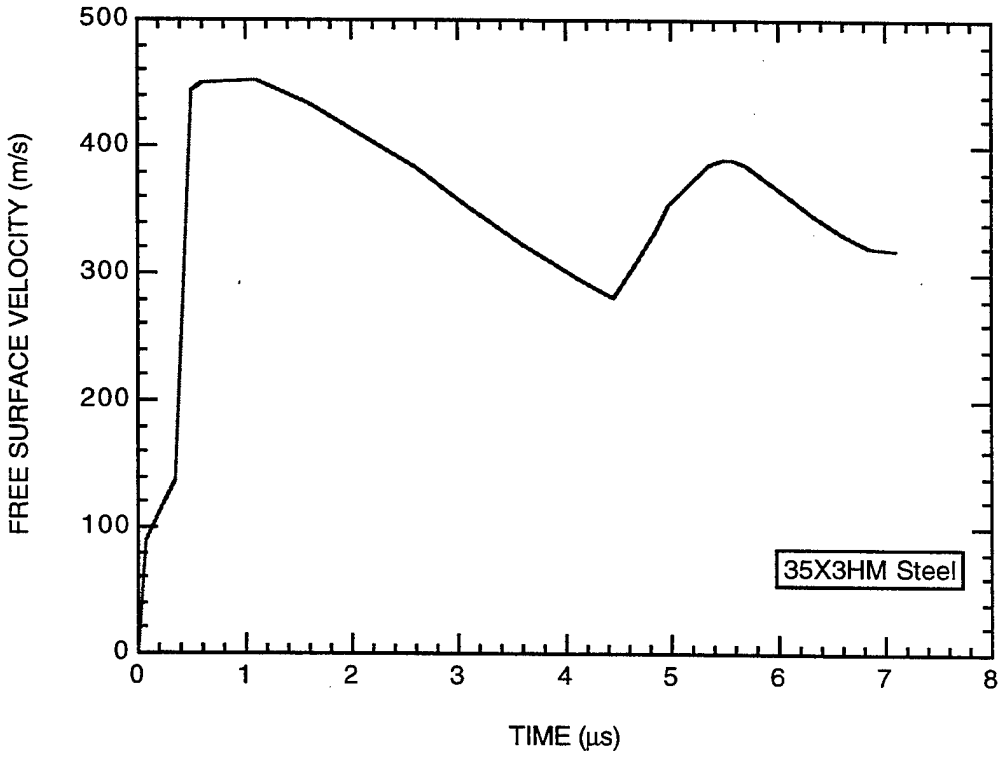


Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	35X3HM steel[1] 15.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[2]	3.4±0.2 GPa 9.4 mm (±10%)

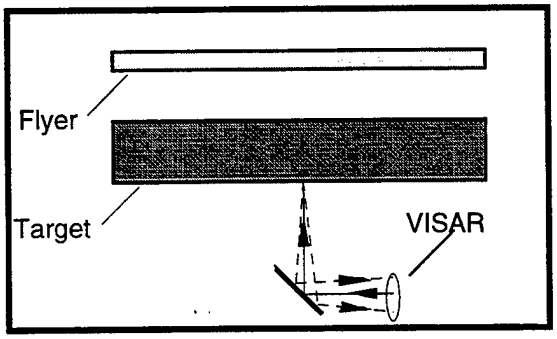
Reference: Gluzman et al. (1985)

[1] Rod - Batch I - loaded in the lateral direction.

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



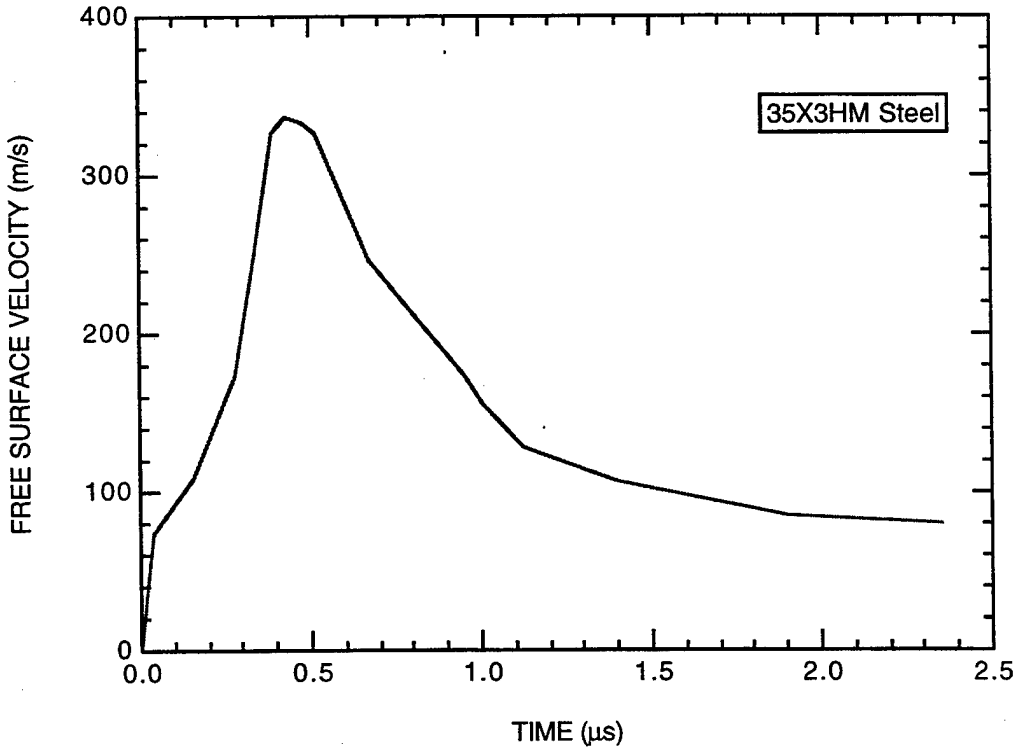
35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs



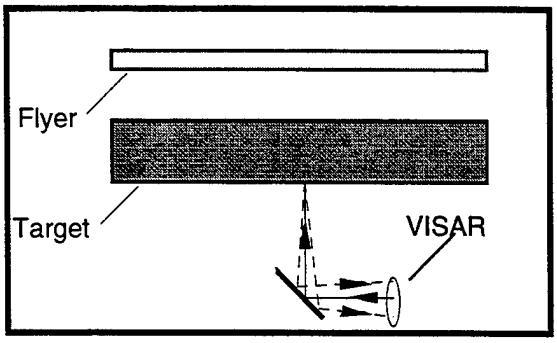
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	35X3HM steel[1] 11.5 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	No spall

Reference: Razorenov et al. (1992)

[1] Rod - Batch II.



35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs

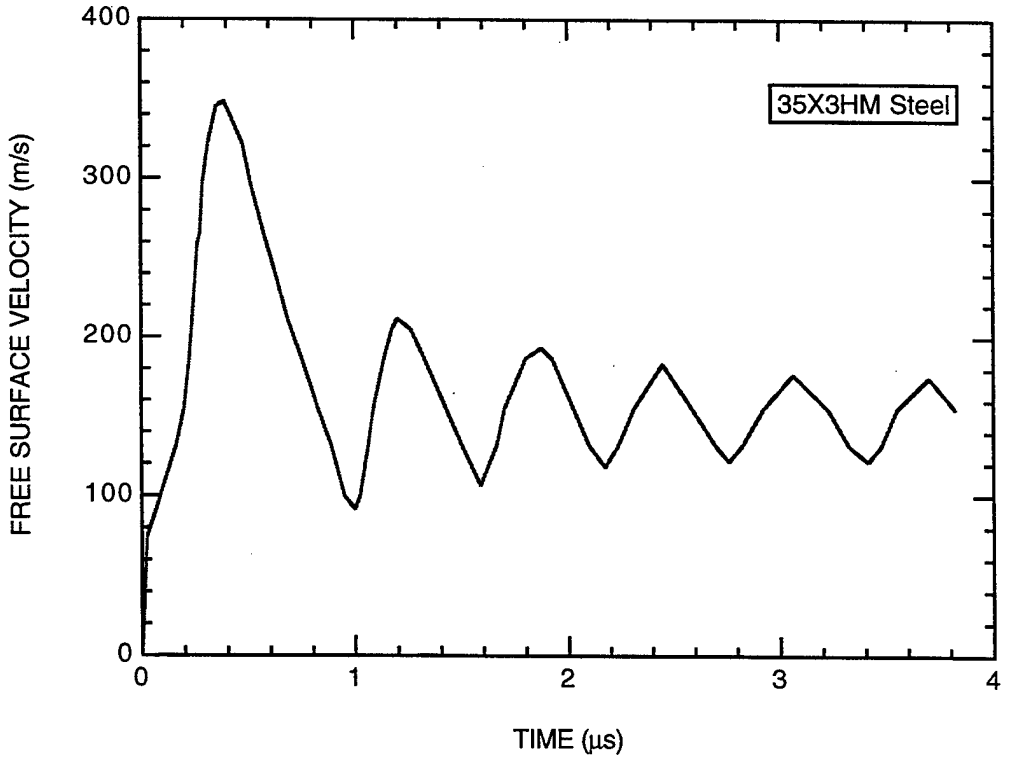


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	720±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	35X3HM steel[1] 10.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	5.06±0.05 GPa 1.63 mm (±10%)

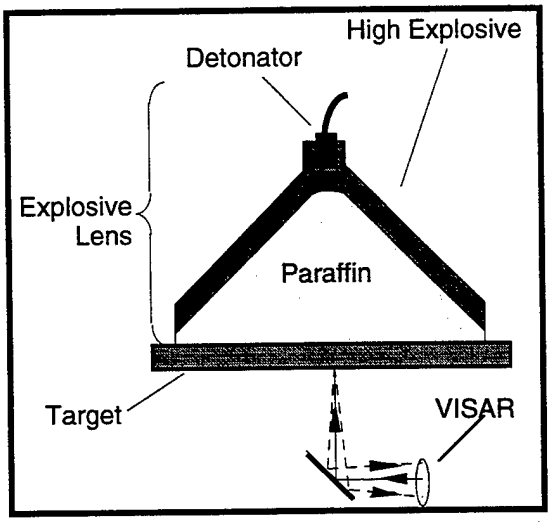
Reference: Razorenov et al. (1992)

[1] Rod - Batch II.

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



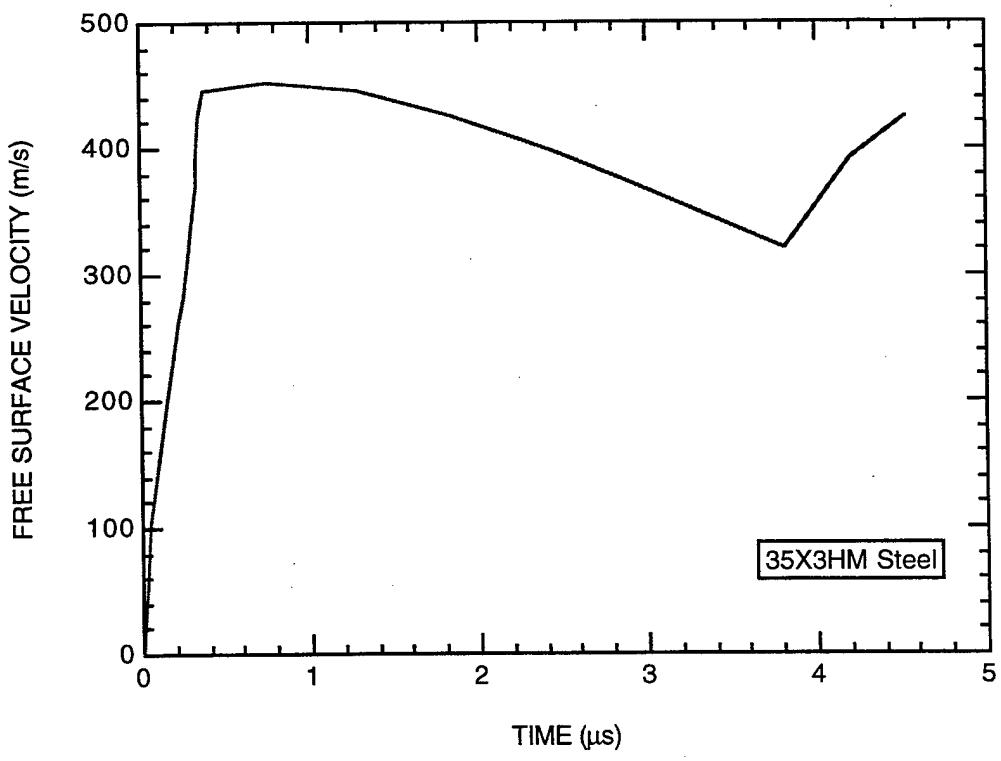
35X3HM Steel	
Density	7.76 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.89 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosive
Target: - material - thickness	35X3HM steel[1] 11.5 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	No spall

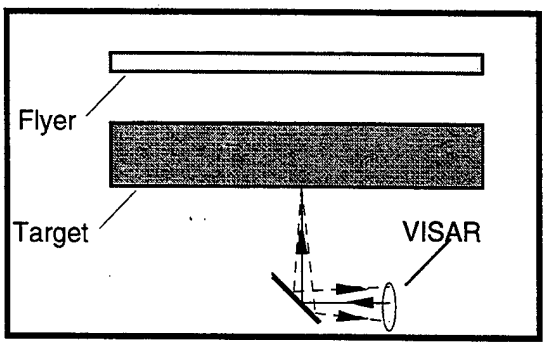
Reference: Razorenov et al. (1992)

[1] Rod - Batch II.



B.6 STEEL 45.

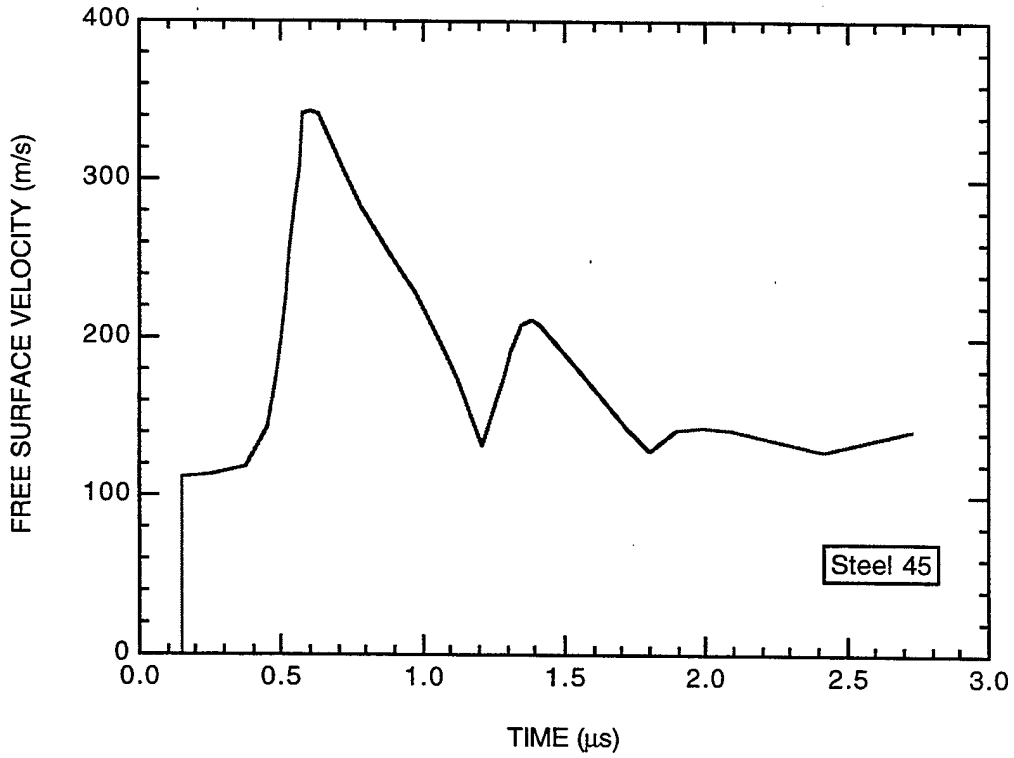
Steel 45	
Density	7.78 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.98 mm/μs



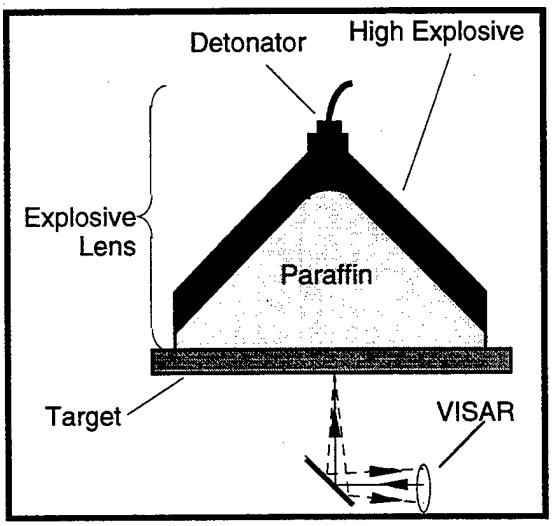
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Steel 45 (rod) 11.1 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	4.25±0.1 GPa 1.81 mm (±10%)

Reference: Razorenov et al. (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.

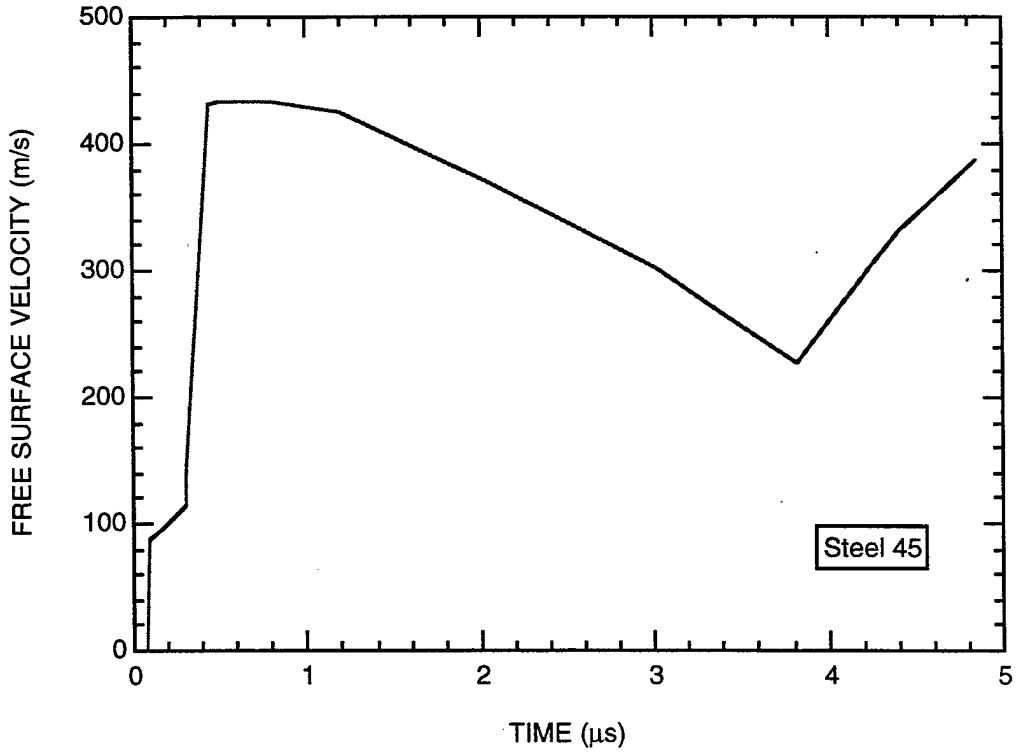


Steel 45	
Density	7.78 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.98 mm/μs



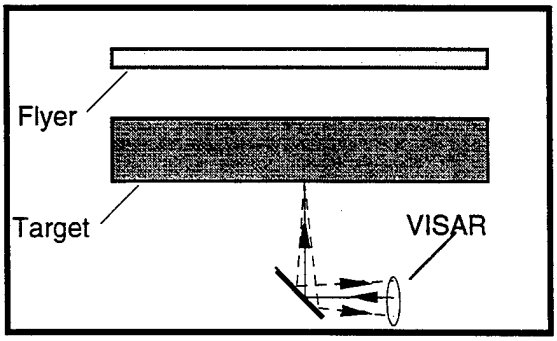
Experiment Summary	
Loading condition	1-D strain
Loading method	In-contact explosives
Target: - material	Steel 45 (rod)
- thickness	11.1 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	No spall

Reference: Razorenov et al. (1992)



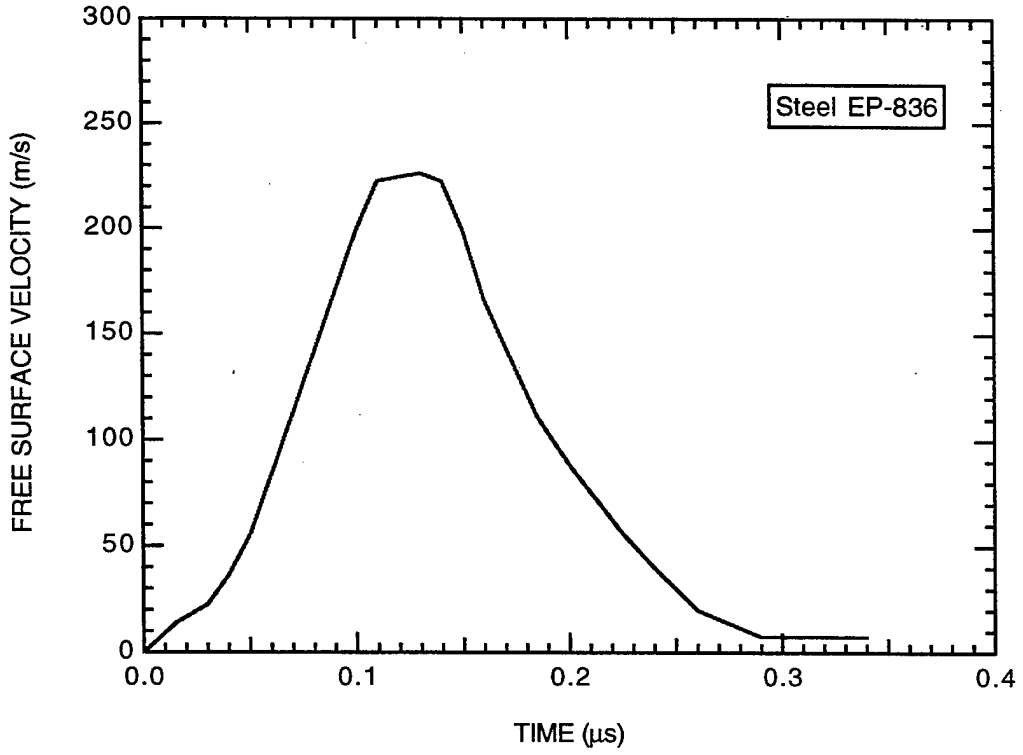
B.7 STEEL EP-836.

Steel EP-836	
Density	8.43 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.62 mm/μs

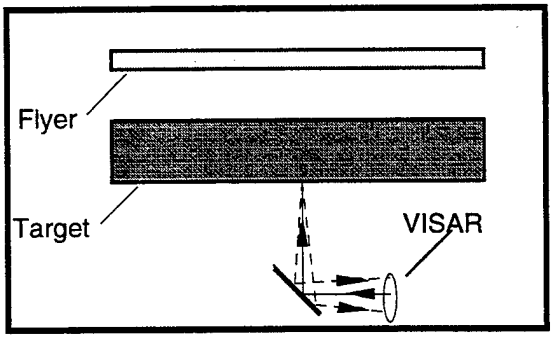


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	720±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Steel EP-836 (rod) 3.75 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	No spall

Reference: Razorenov et al. (1992)



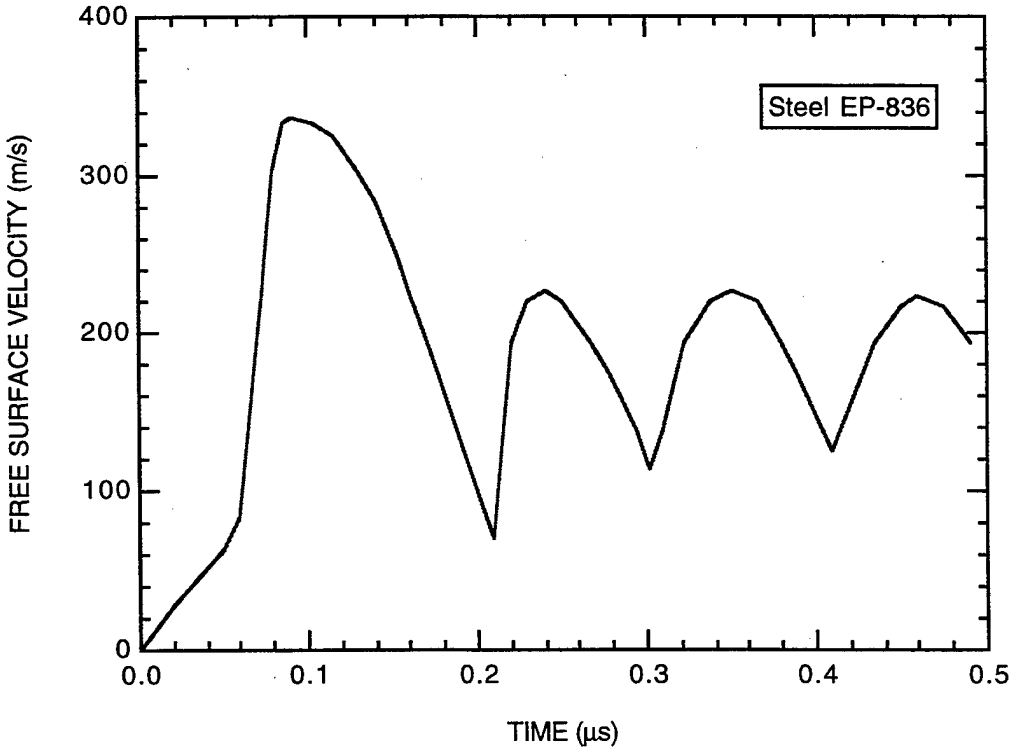
Steel EP-836	
Density	8.43 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.62 mm/μs



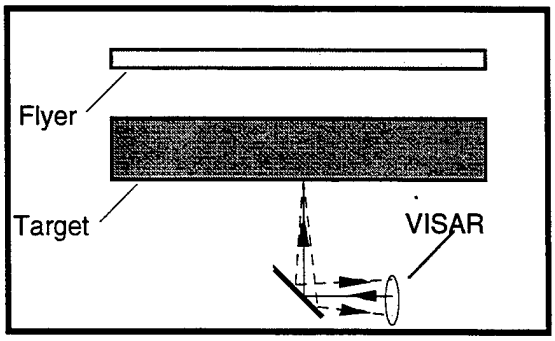
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	720±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Steel EP-836 (rod) 1.95 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	5.94±0.1 GPa 0.29 mm (±10%)

Reference: Razorenov et al. (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



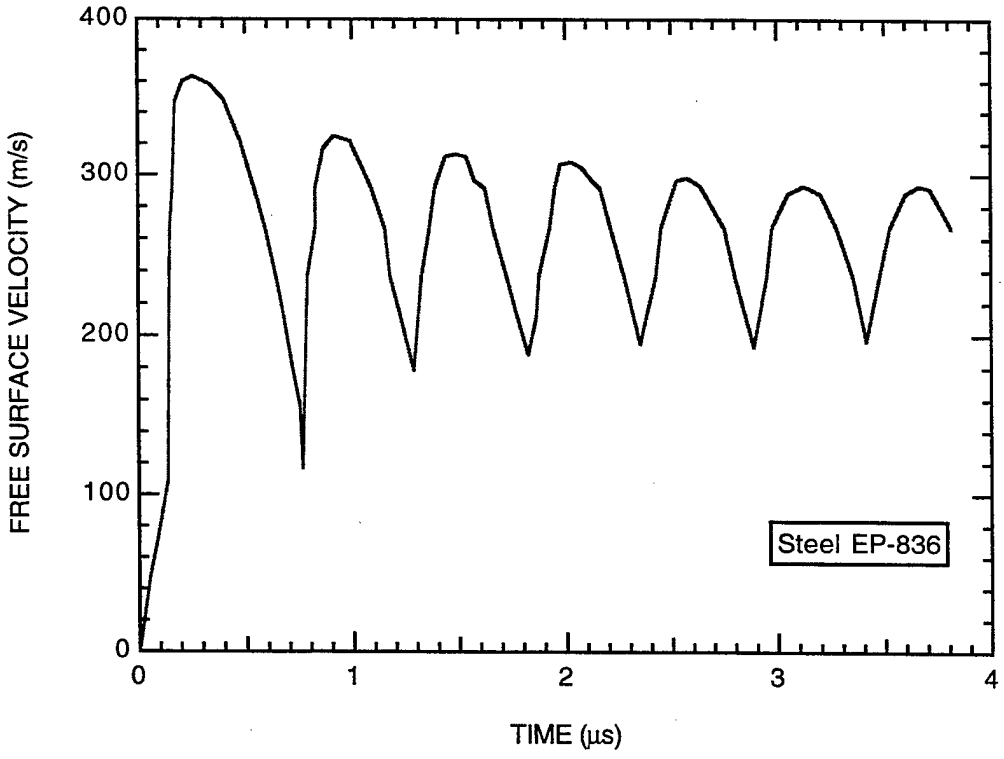
Steel EP-836	
Density	8.43 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.62 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	720±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Steel EP-836 (rod) 5.42 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	6.19±0.1 GPa 1.496 mm (±10%)

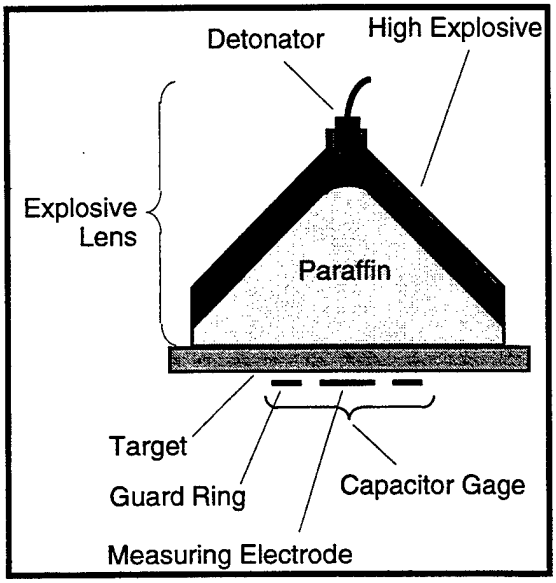
Reference: Razorenov et al. (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.8 STAINLESS STEEL (KH18N10T).

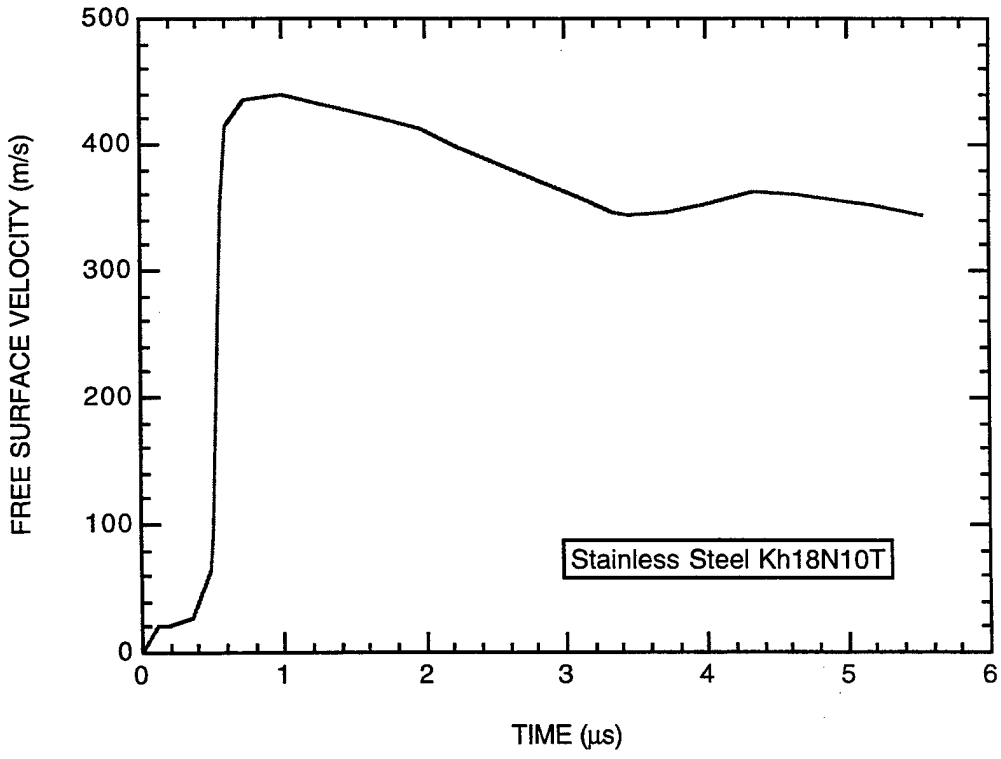
Stainless Steel (Kh18N10T)	
Density	7.90 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.74 mm/μs



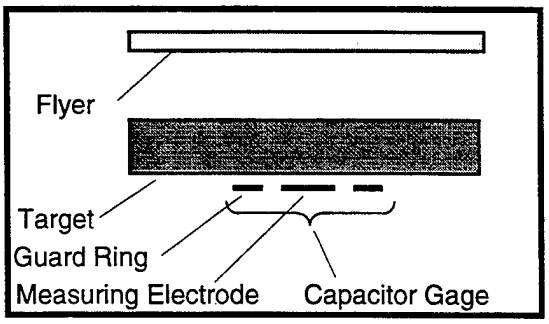
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	Kh18N10T steel (rod) 15 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.73±0.11 GPa 6.9 mm (±10%)

Reference: Kanel (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.

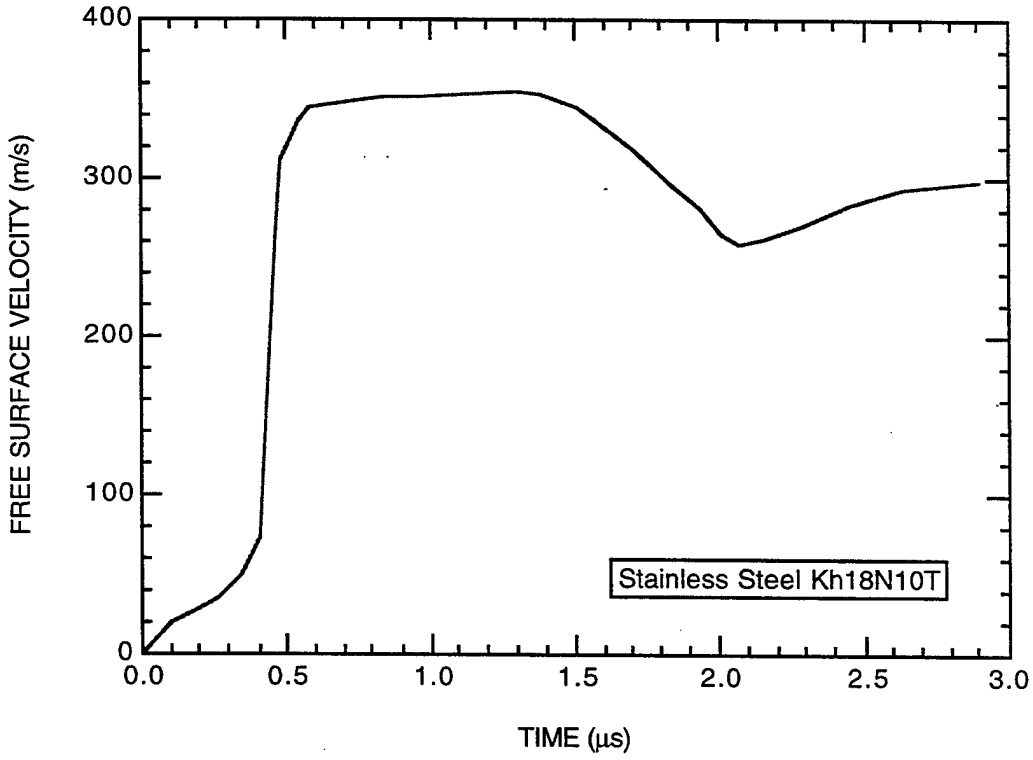


Stainless Steel (Kh18N10T)	
Density	7.90 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.74 mm/μs

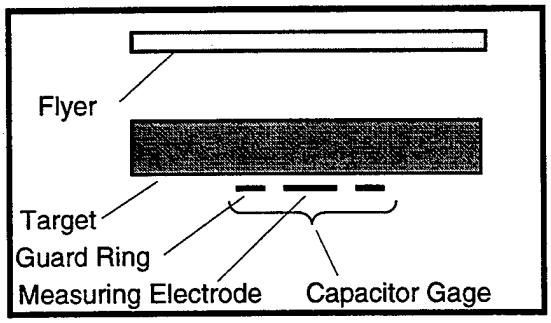


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±10 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Kh18N10T steel(rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength	1.75±0.11 GPa

Reference: Kanel (1980)



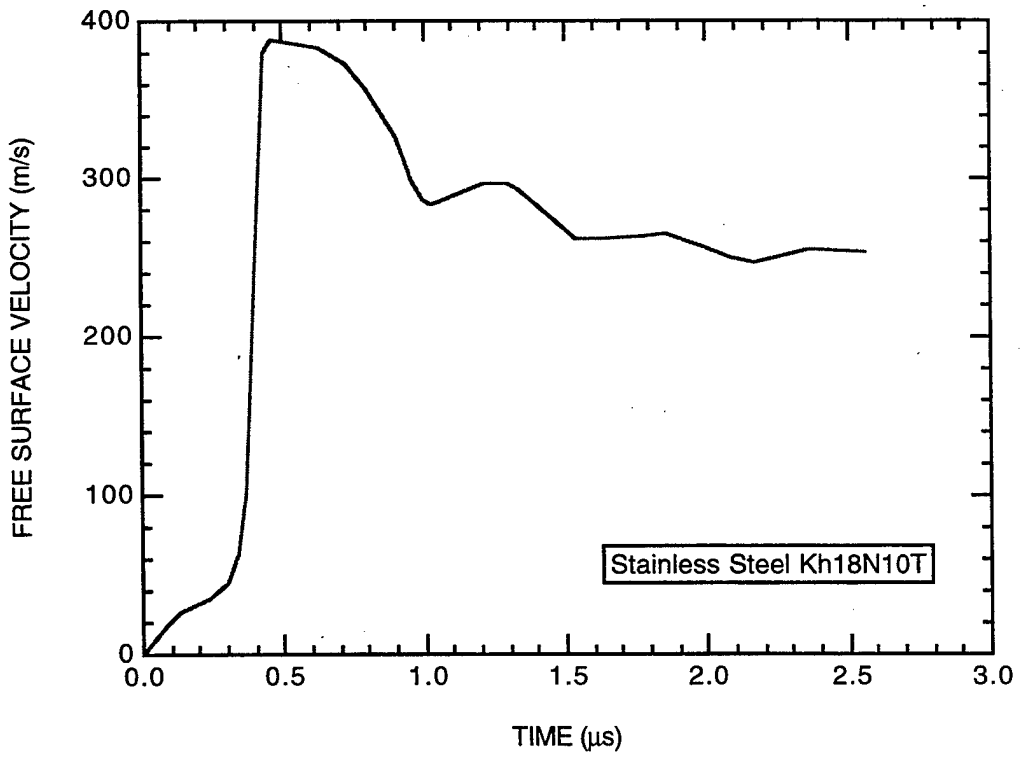
Stainless Steel (Kh18N10T)	
Density	7.90 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.74 mm/μs



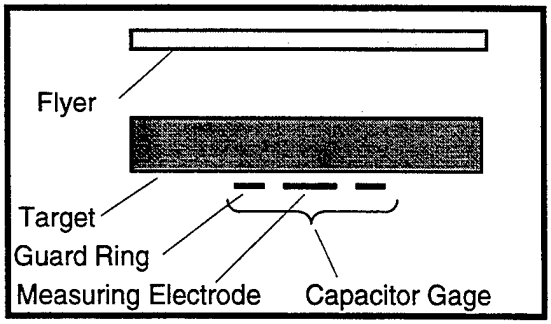
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±30 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Kh18N10T steel (rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.93±0.09 GPa 1.61 mm (±10%)

Reference: Kanel (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



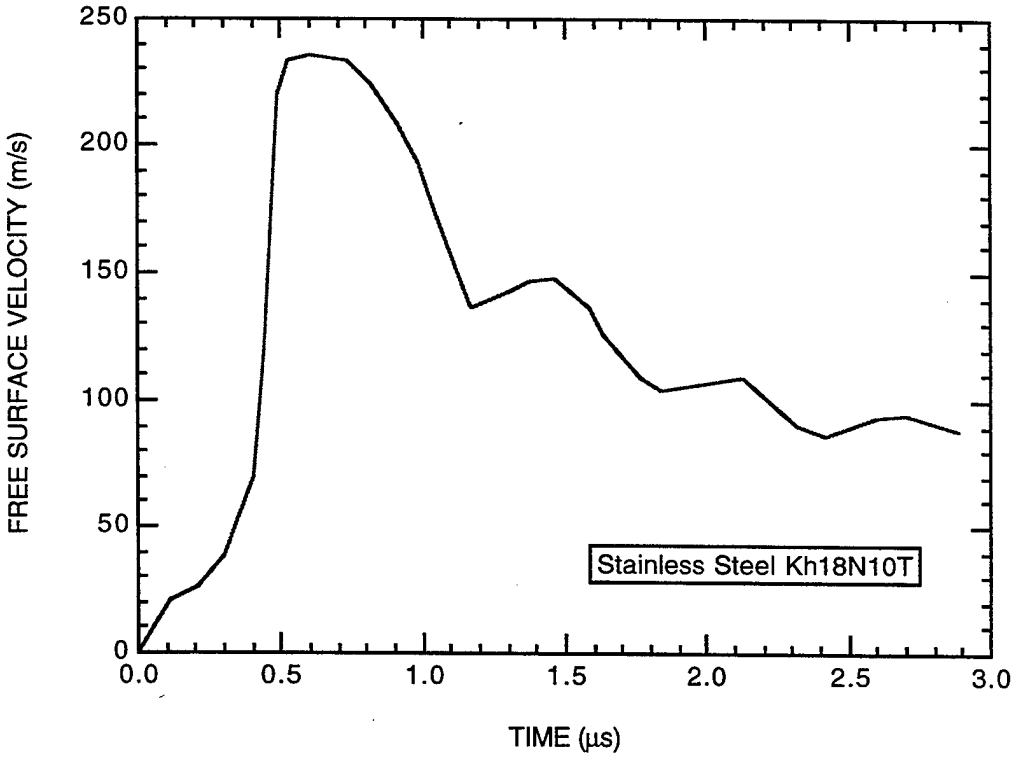
Stainless Steel (Kh18N10T)	
Density	7.90 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.74 mm/μs



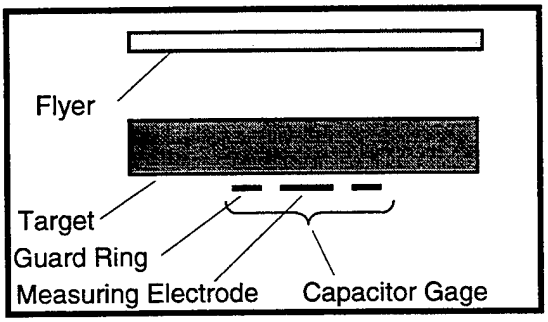
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	445±15 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Kh18N10T steel (rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.93±0.13 GPa 1.78 mm (±10%)

Reference: Kanel (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.

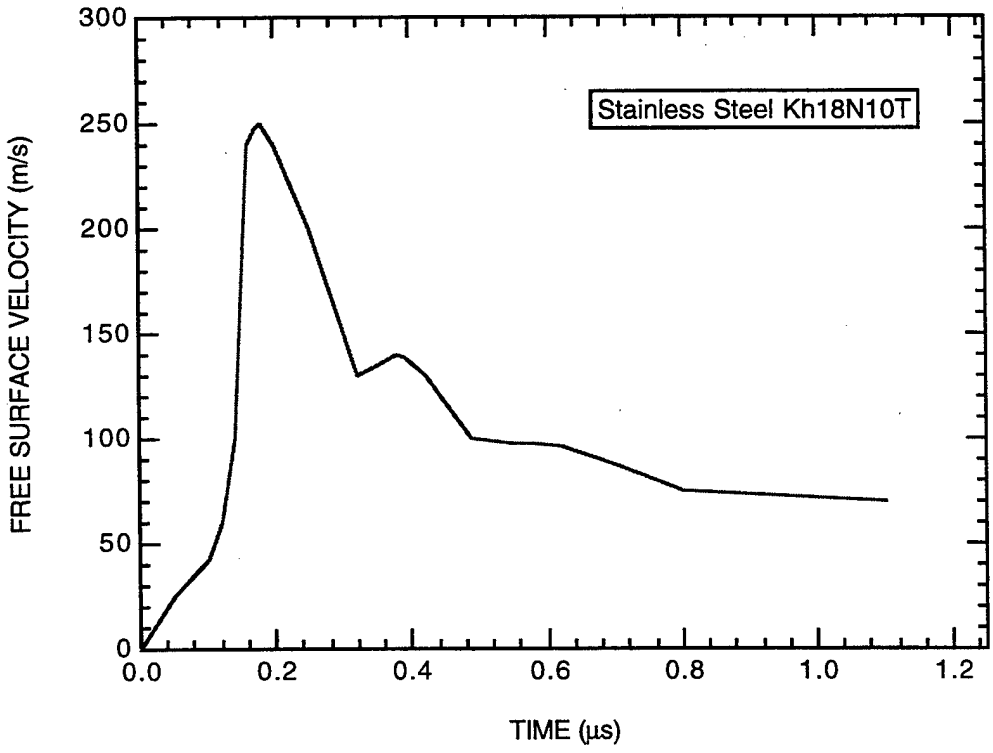


Stainless Steel (Kh18N10T)	
Density	7.90 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.74 mm/μs



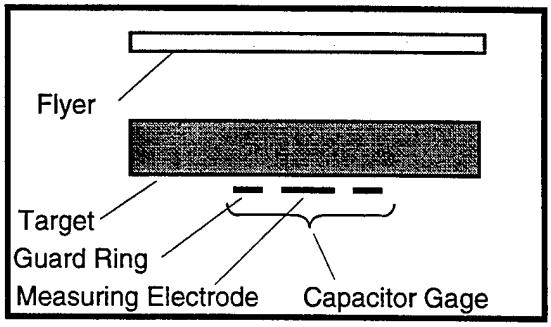
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±30 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Kh18N10T stee (rod) 4 mm
Measurement technique Electrode diameter	Capacitor gage 5 mm
Measurement accuracy	±4%
Spall strength Spall thickness	2.28±0.1 GPa 0.65 mm (±10%)

Reference: Kanel and Razorenov (1989)



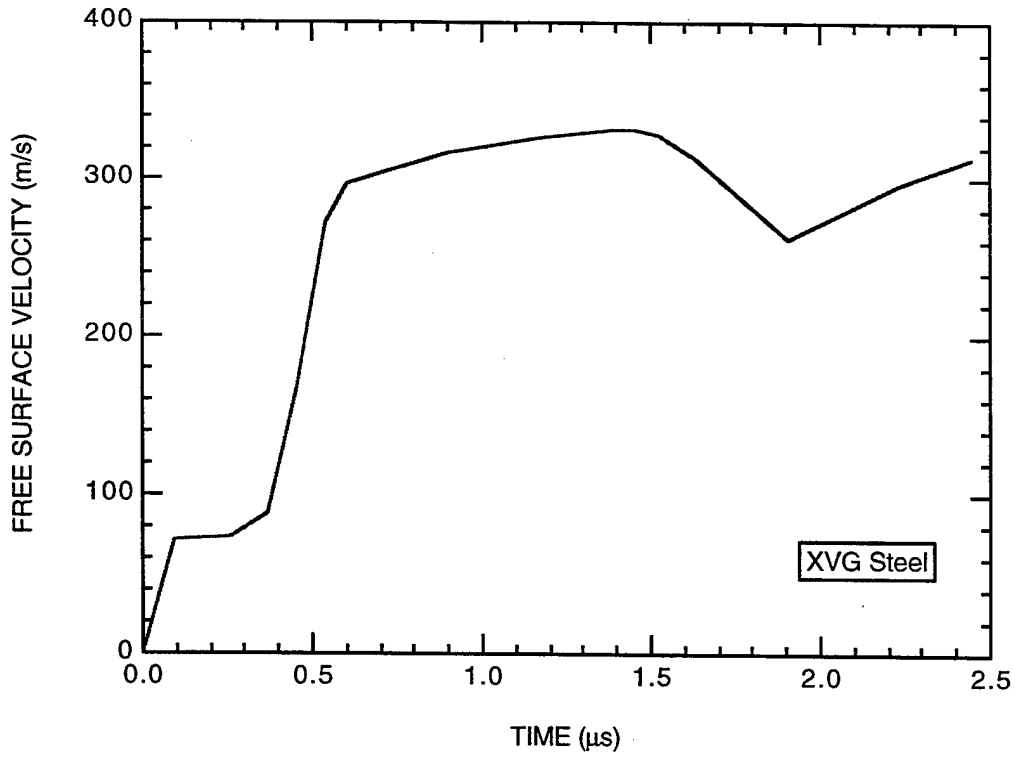
B.9 STEEL XVG[1].

Steel XVG	
Density	7.95 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.85 mm/μs



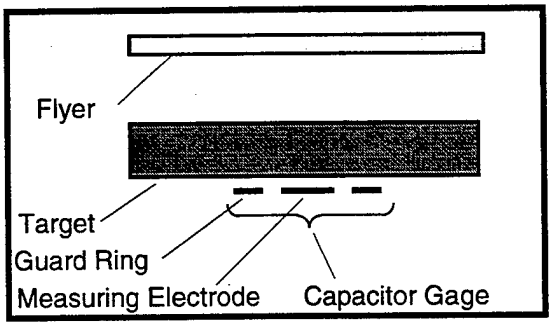
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Steel XVG (rod-as received) 10.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Kanel and Razorenov (1989)



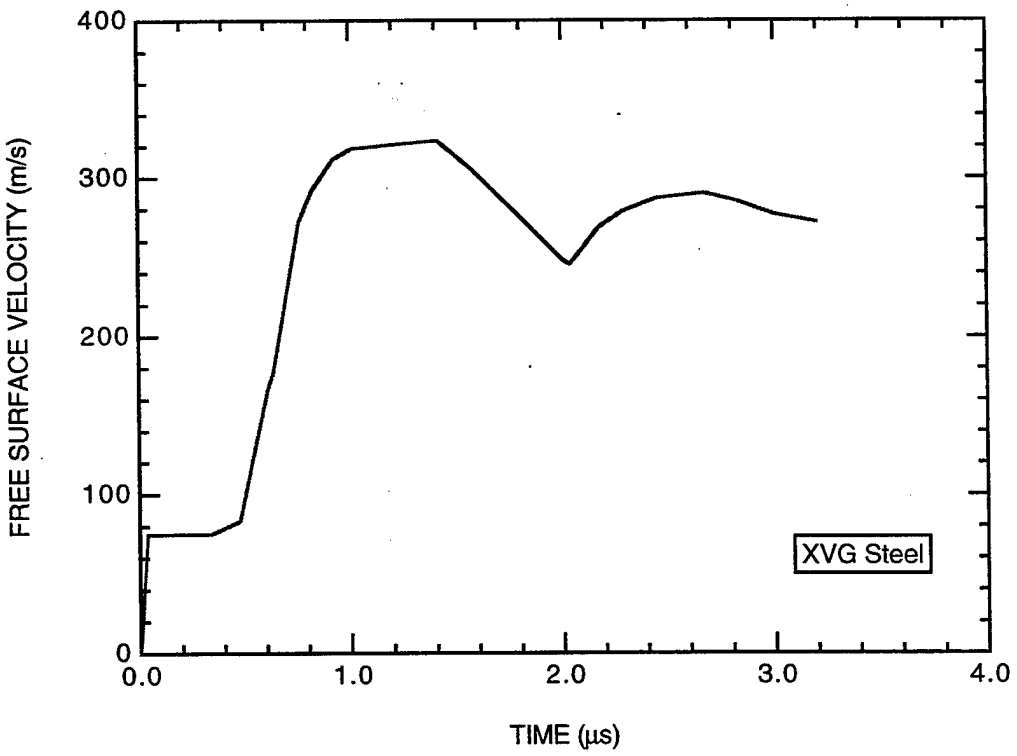
[1] The designation XVG is in Russian letters. The equivalent designation in English letters is KhVG.

Steel XVG	
Density	7.95 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.85 mm/μs

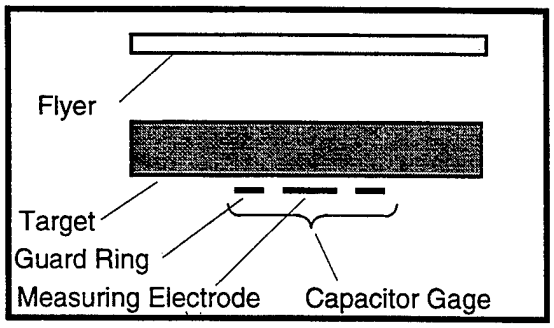


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Steel XVG (rod-as received) 15.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Kanel and Razorenov (1989)

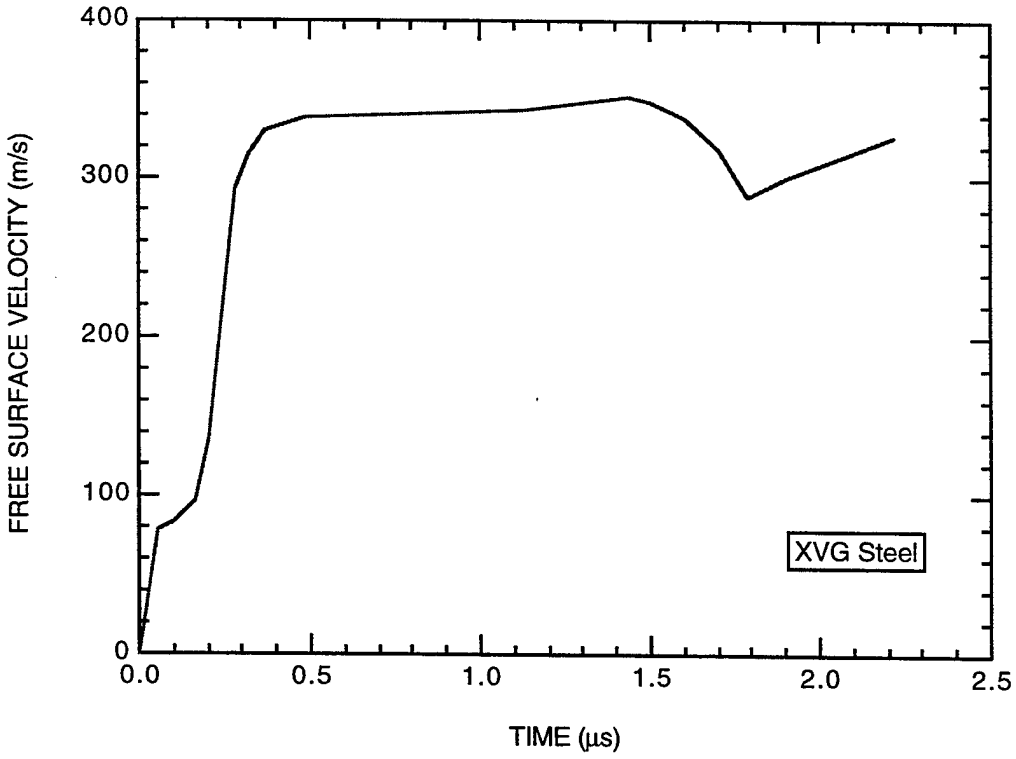


Steel XVG	
Density	7.95 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.85 mm/μs

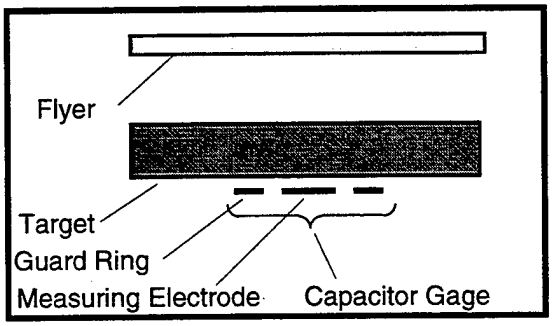


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Steel XVG (rod-as received) 5.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Kanel and Razorenov (1989)

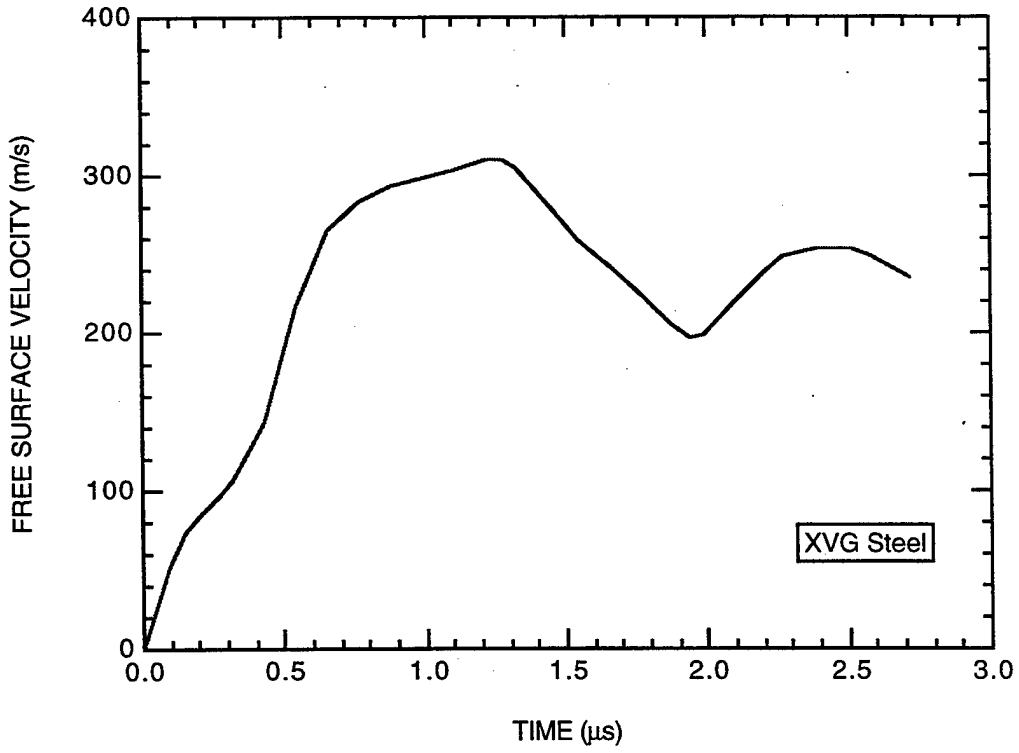


Steel XVG	
Density	7.95 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.85 mm/μs

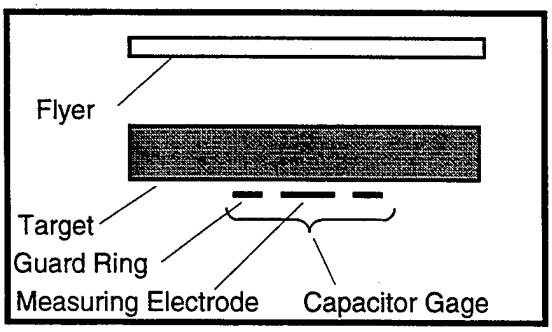


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Steel XVG (rod-quenched) 20.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Kanel and Razorenov (1989)

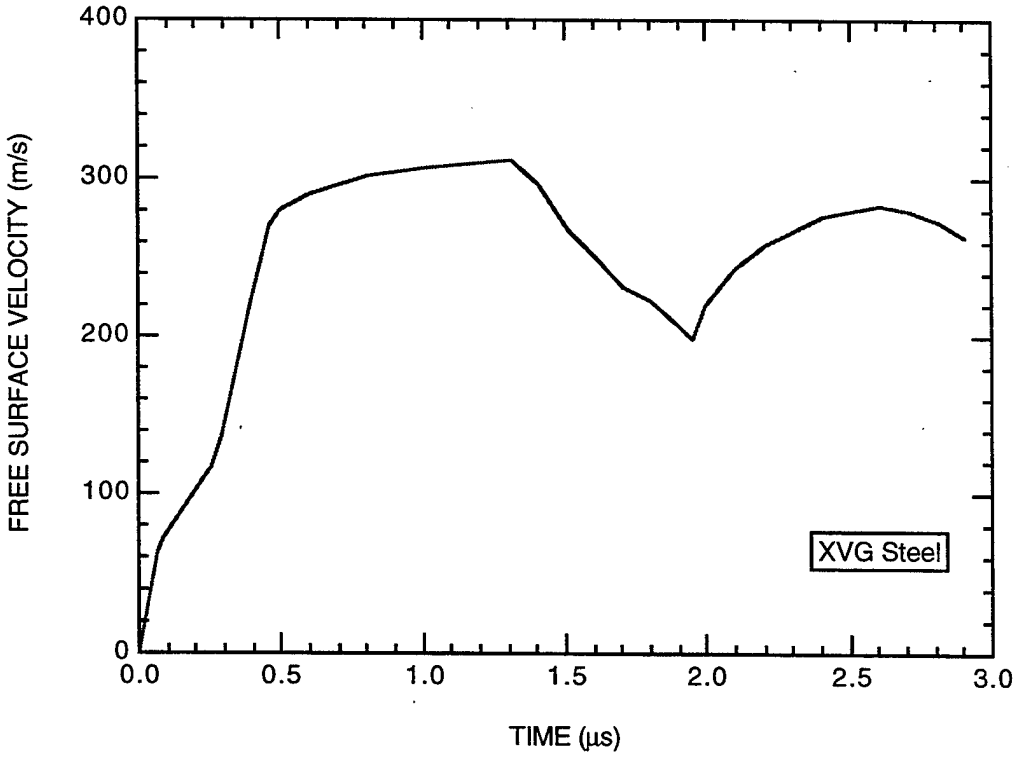


Steel XVG	
Density	7.95 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.85 mm/μs

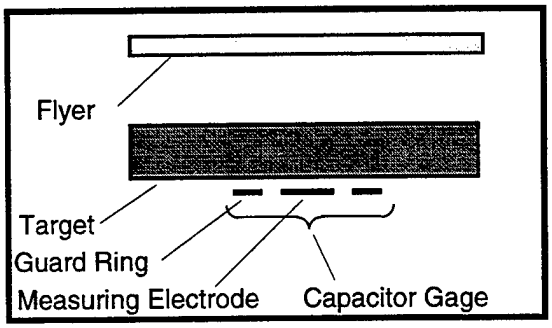


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Steel XVG (rod-quenched) 15.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Kanel and Razorenov (1989)

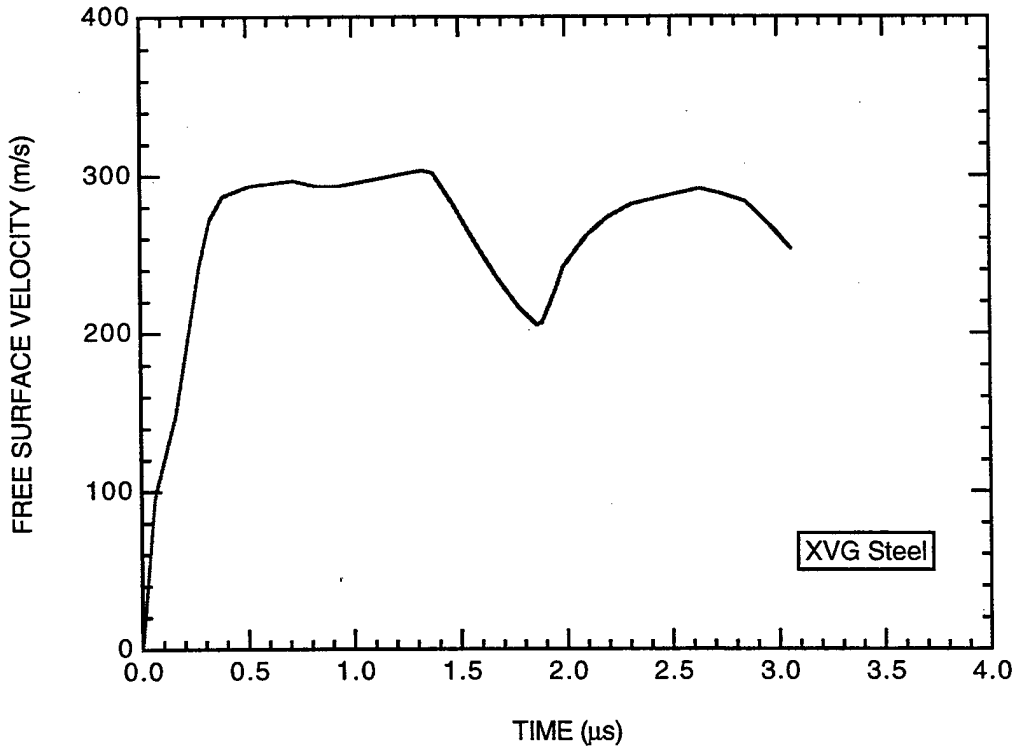


Steel XVG	
Density	7.95 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.85 mm/μs



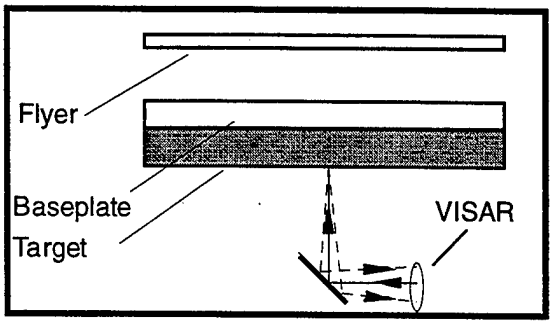
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Steel XVG (rod-quenched) 10.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Kanel and Razorenov (1989)



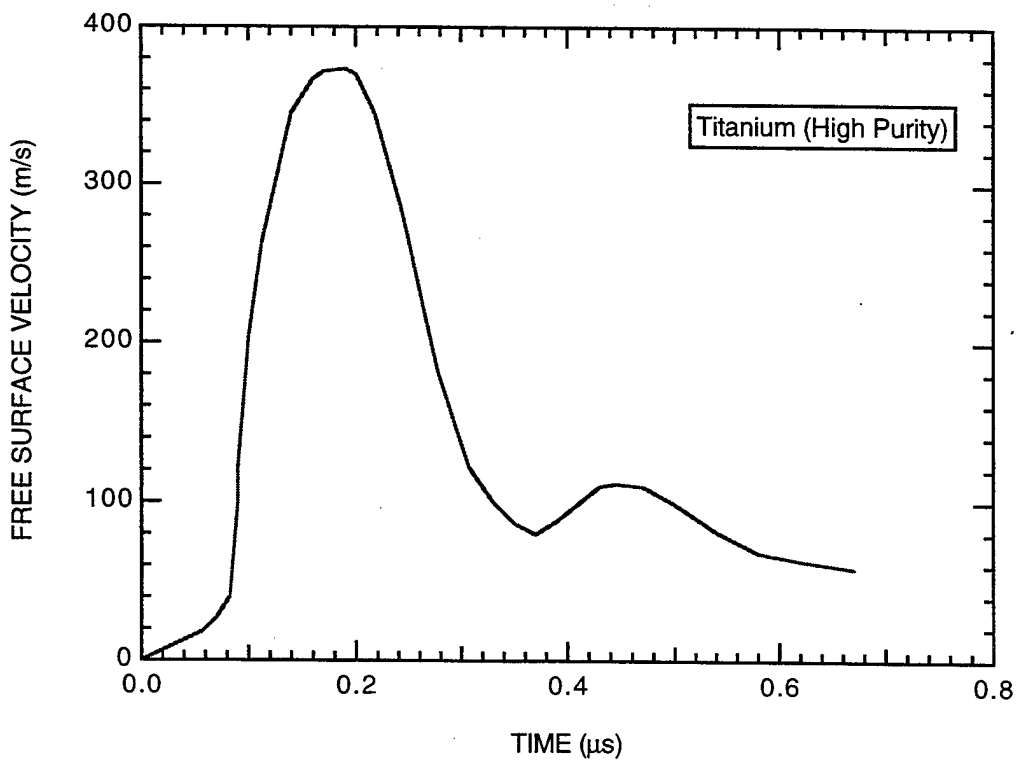
B.10 HIGH PURITY TITANIUM.

High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs

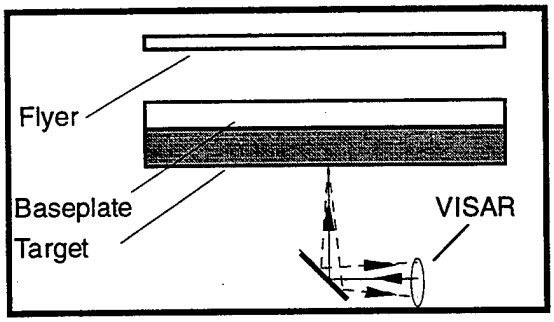


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 0.78 mm
Target: - material - thickness	Titanium of high purity 2.06 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	3.2±0.2 GPa

Razorenov et al. (1995)



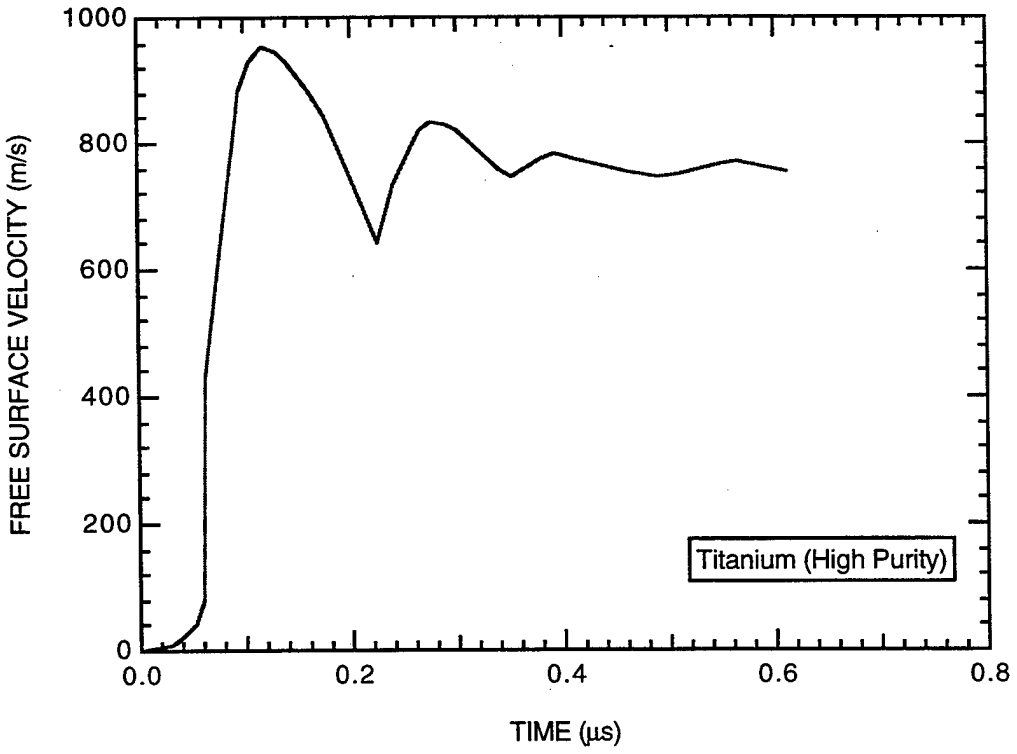
High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



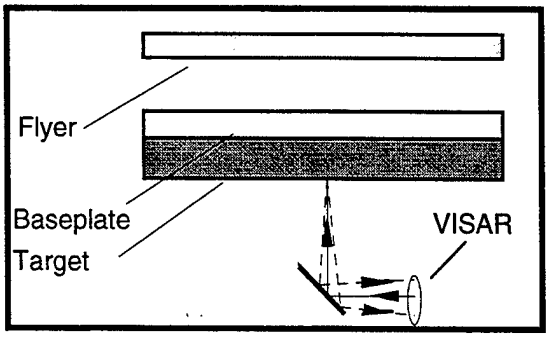
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1250±50 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 0.77 mm
Target: - material - thickness	Titanium of high purity 2.29 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	3.34±0.2 GPa 0.37 mm (±10%)

Razorenov et al. (1995)

[1] Determined based on the period of oscillation in the measured velocity history.



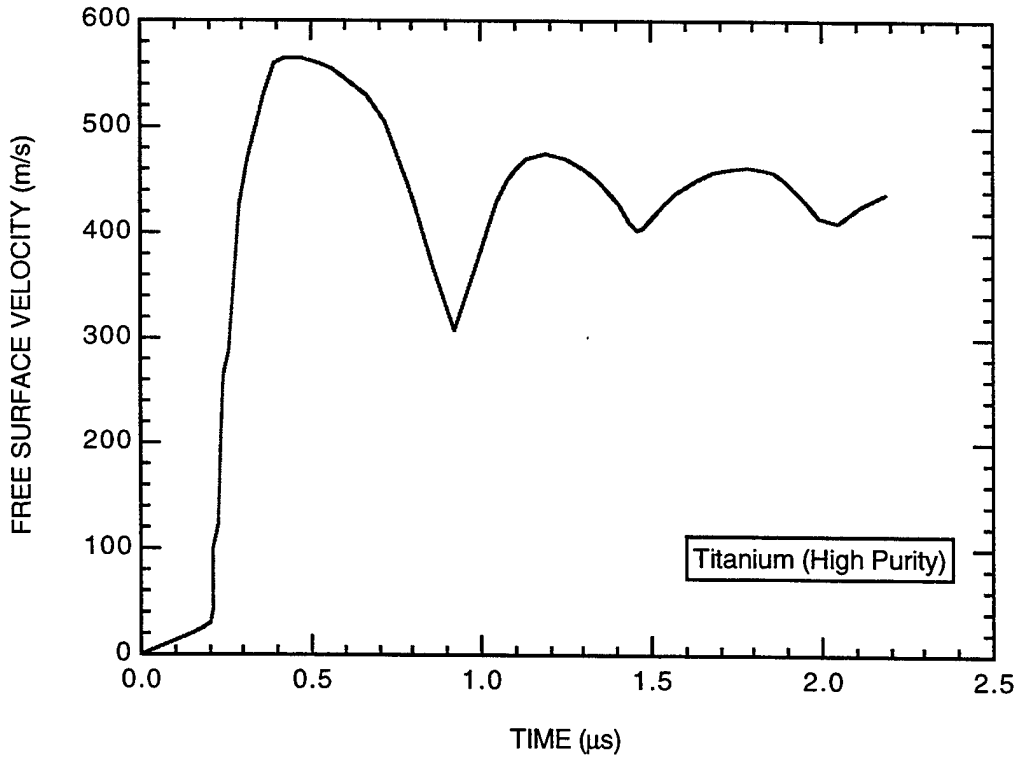
High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



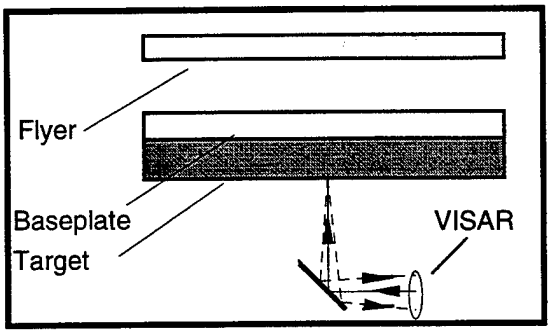
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Titanium of high purity 4.4 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	2.81±0.1 GPa 1.54 mm (±10%)

Razorenov et al. (1995)

[1] Determined based on the period of oscillation in the measured velocity history.



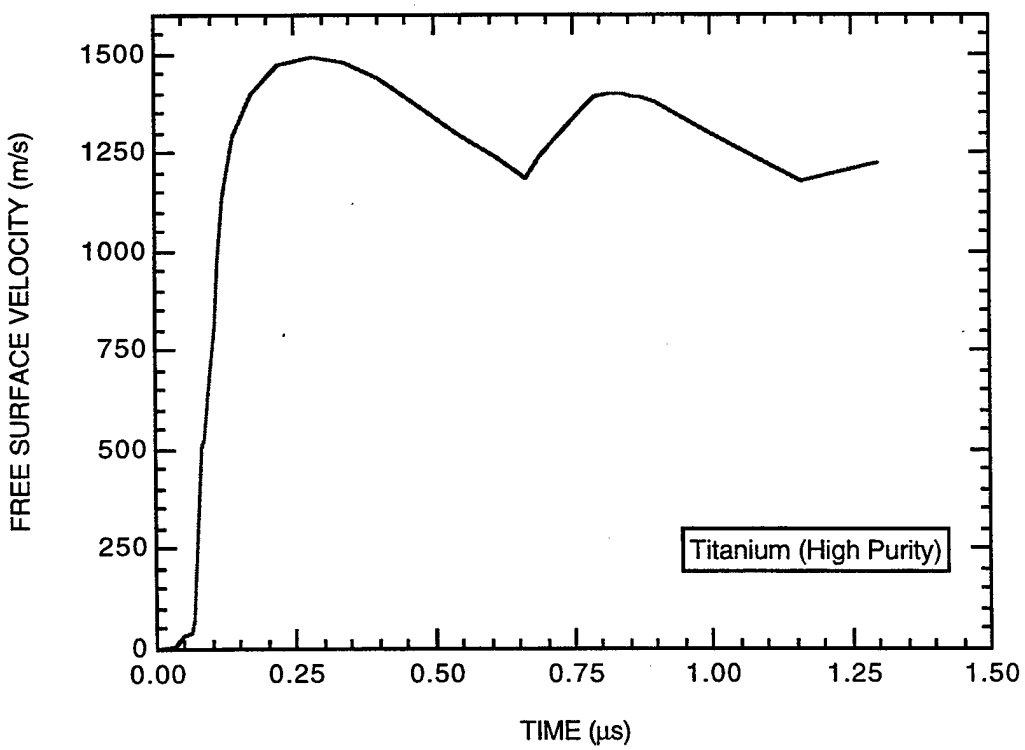
High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



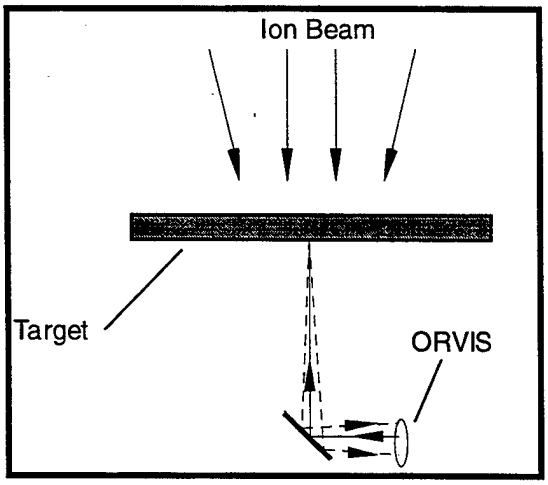
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Titanium of high purity 4.3 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	3.47±0.1 GPa 1.43 mm (±10%)

Razorenov et al. (1995)

[1] Determined based on the period of oscillation in the measured velocity history.

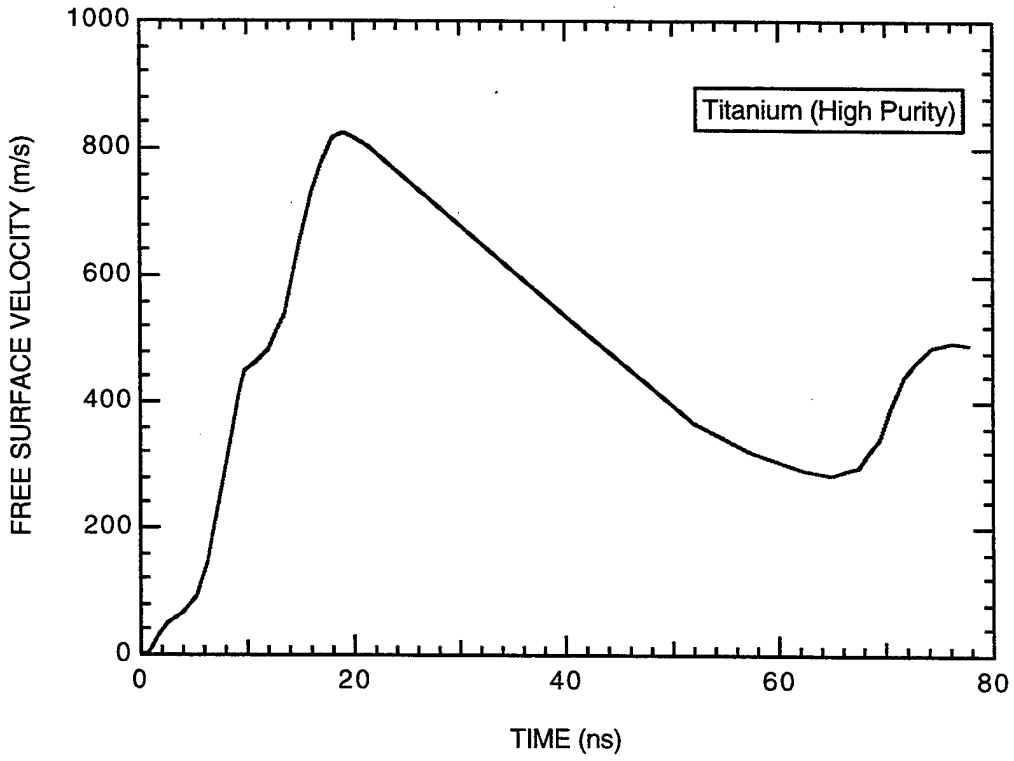


High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs

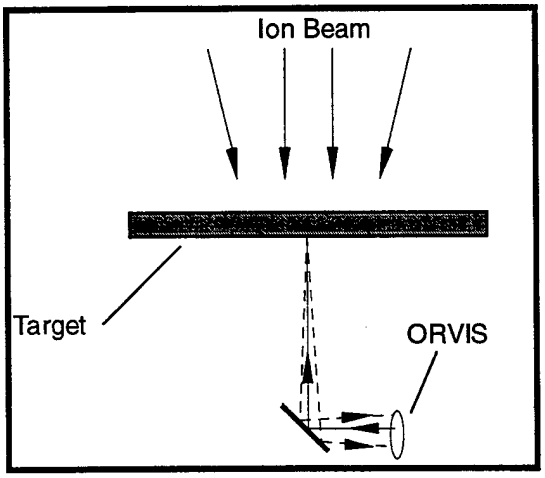


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Titanium of high purity 0.78 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness	6.33±0.1 GPa 0.149 mm (±10%)

Razorenov et al. (1995)



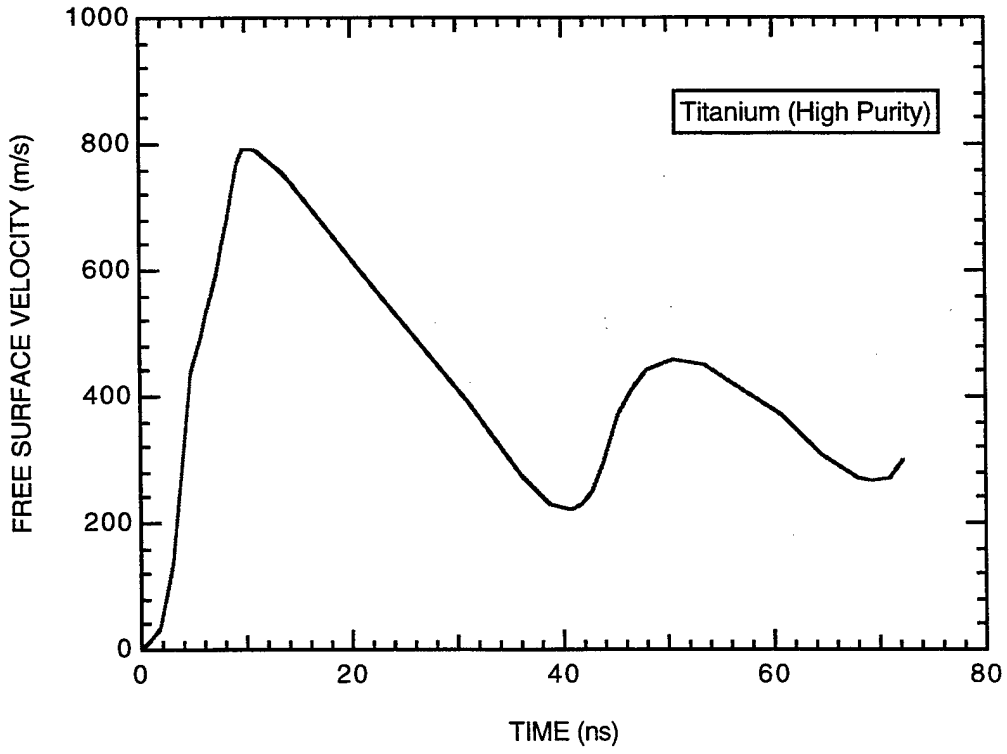
High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



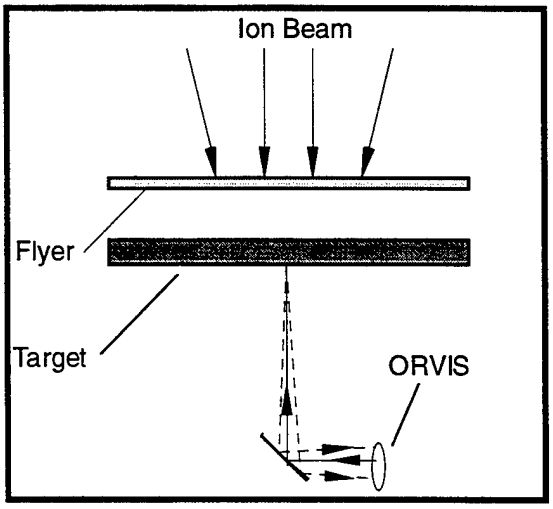
Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Titanium of high purity 0.483 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[1]	6.28±0.1 GPa 0.054 mm (±10%)

Razorenov et al. (1995)

[1] Determined based on the period of oscillation in the measured velocity history.



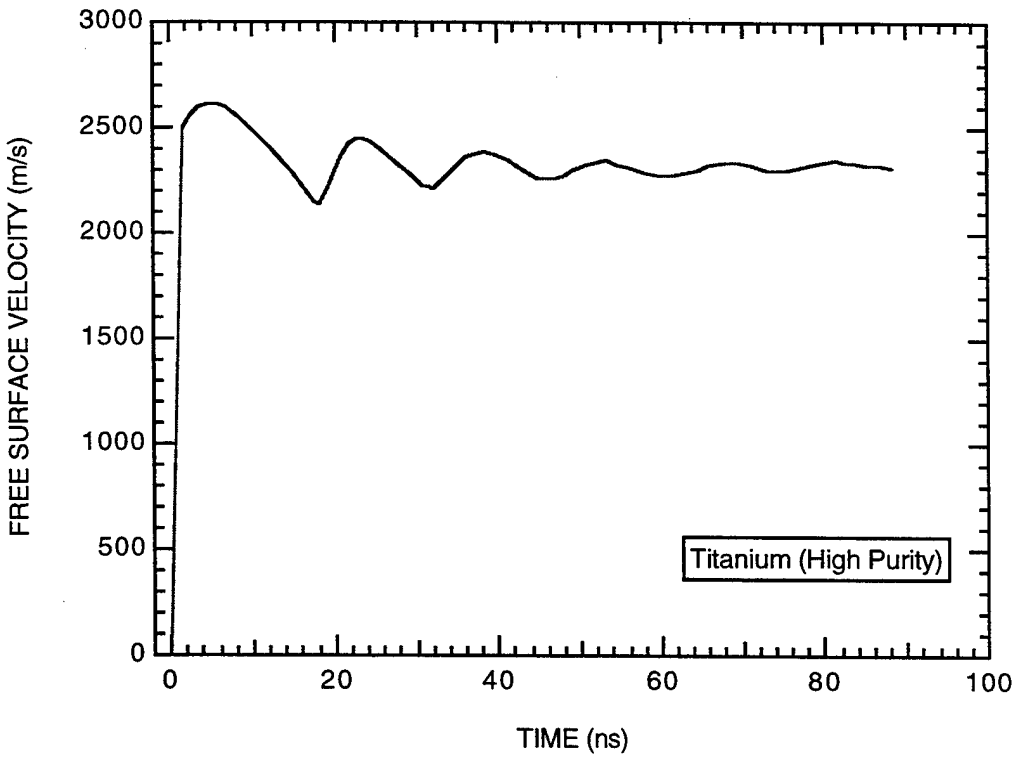
High Purity Titanium	
Density	4.5 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Titanium of high purity 0.78 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[1]	6.33±0.1 GPa 0.041 mm (±10%)

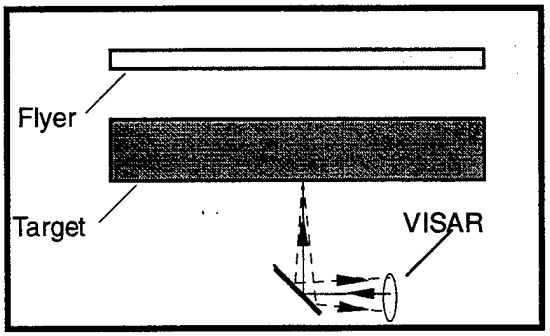
Razorenov et al. (1995)

[1] Determined based on the period of oscillation in the measured velocity history.



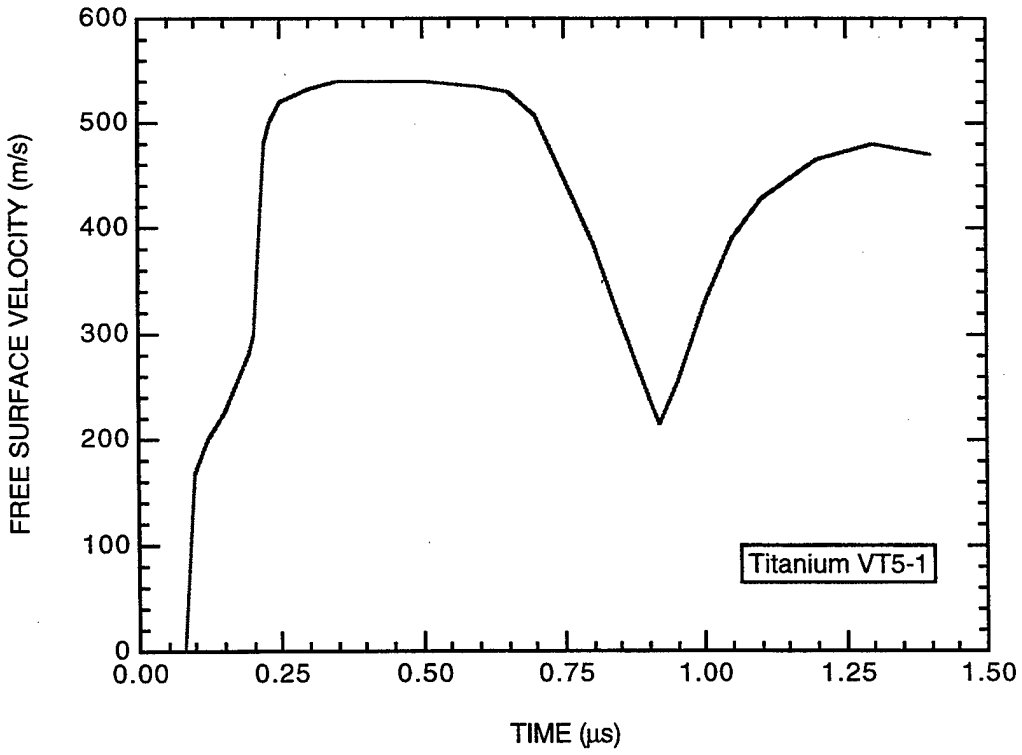
B.11 TITANIUM VT5-1.

Titanium VT5-1	
Density	4.45 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs

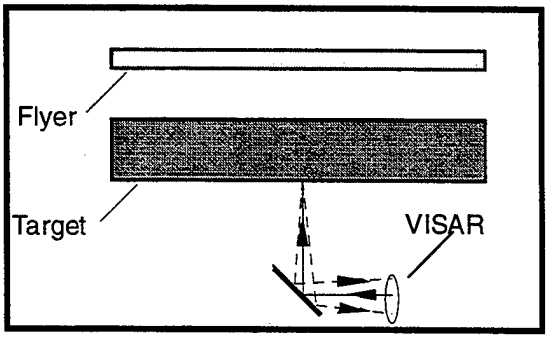


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT5-1 (sheet) 4 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s

Reference: Kanel et al. (1986)

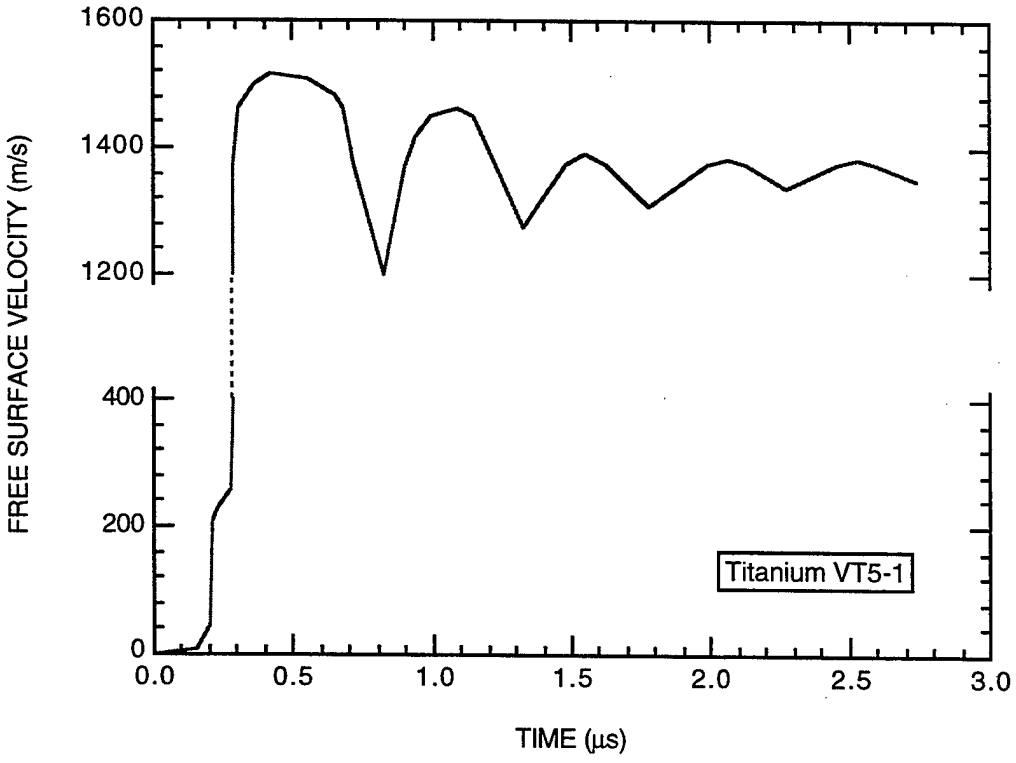


Titanium VT5-1	
Density	4.45 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs

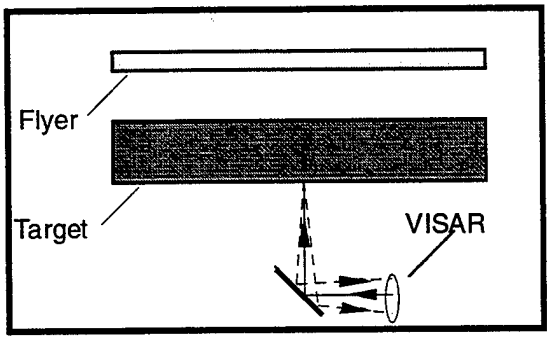


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±100 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT5-1 (sheet) 4 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s

Reference: Kanel et al. (1986)

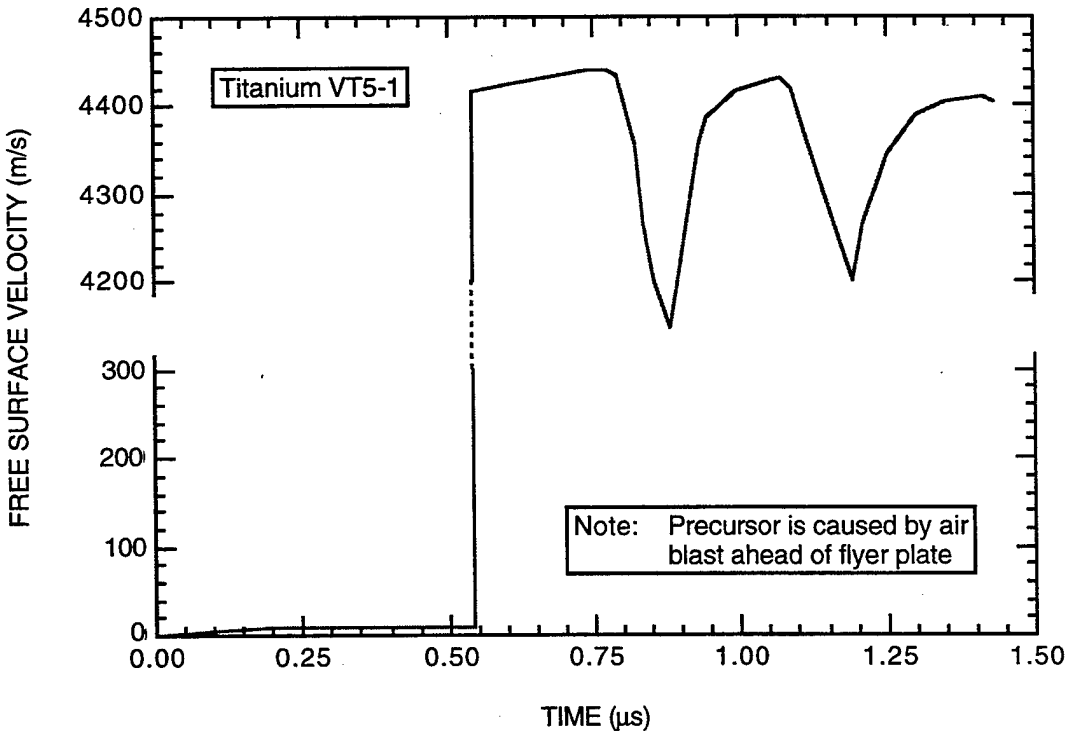


Titanium VT5-1	
Density	4.45 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



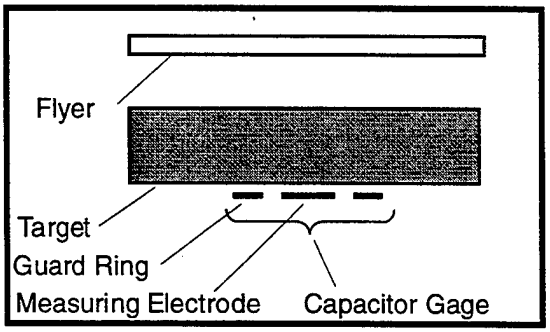
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	5300±100 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT5-1 (sheet) 4 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s

Reference: Kanel et al. (1986)



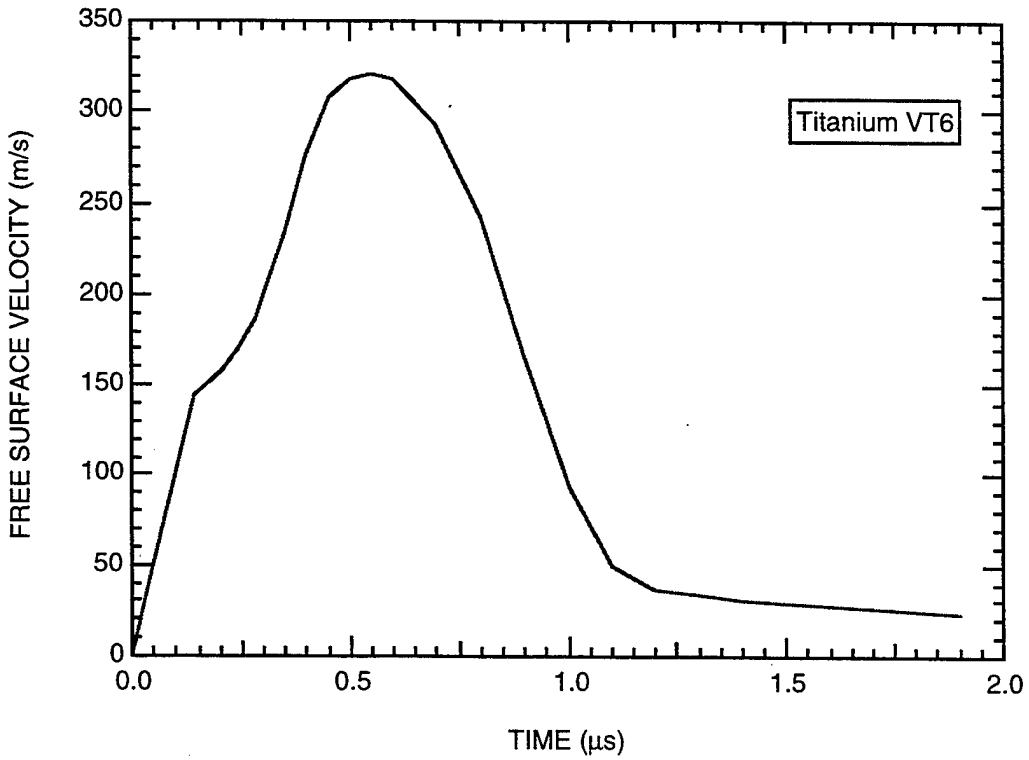
B.12 TITANIUM VT6.

Titanium VT6	
Density	4.43 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs

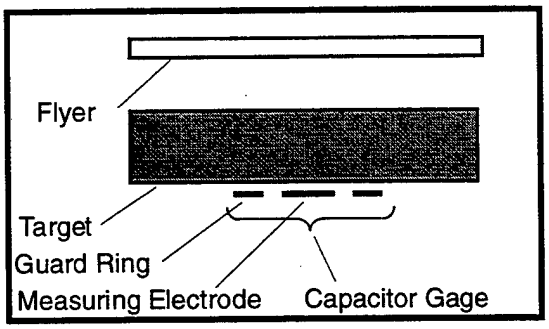


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT6 (sheet) 9.8 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength	No Spall observed

Reference: Kanel and Petrova (1981)



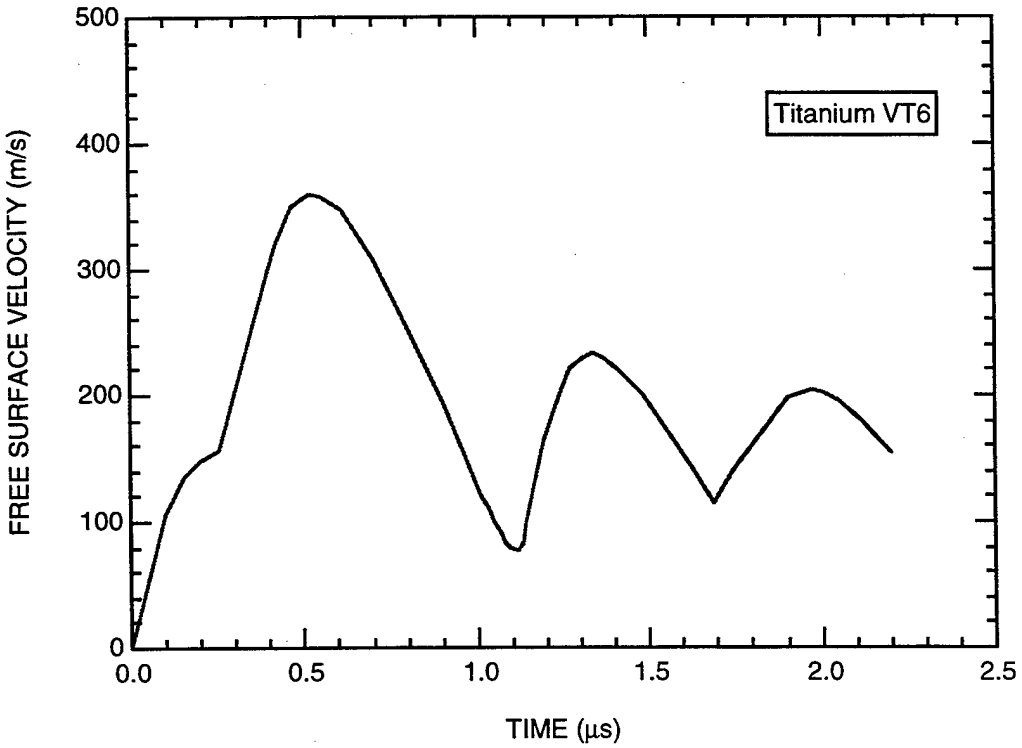
Titanium VT6	
Density	4.43 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



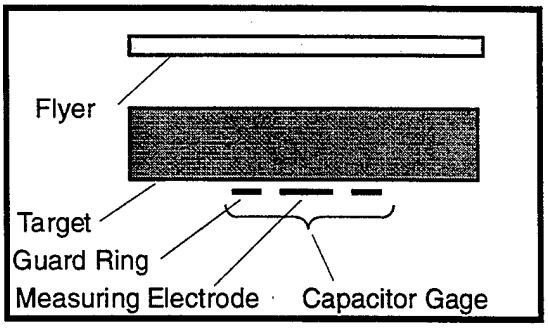
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	675±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT6 (sheet) 11.7 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	3.5±0.2 GPa 1.75 mm (±10%)

Reference: Kanel and Petrova (1981)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



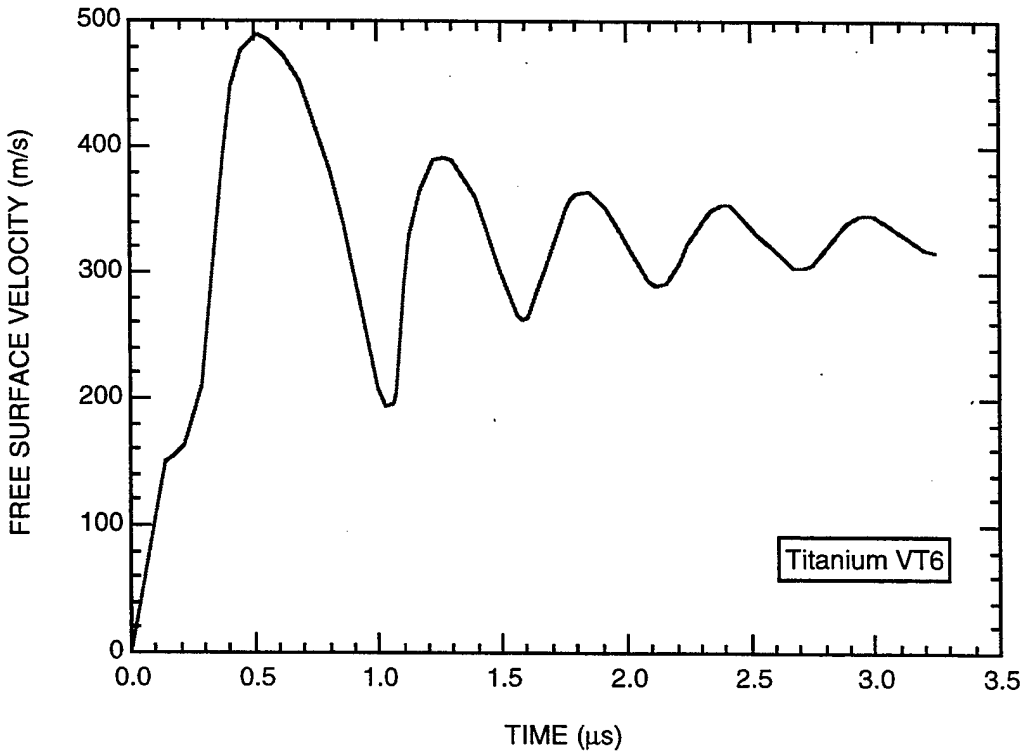
Titanium VT6	
Density	4.43 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



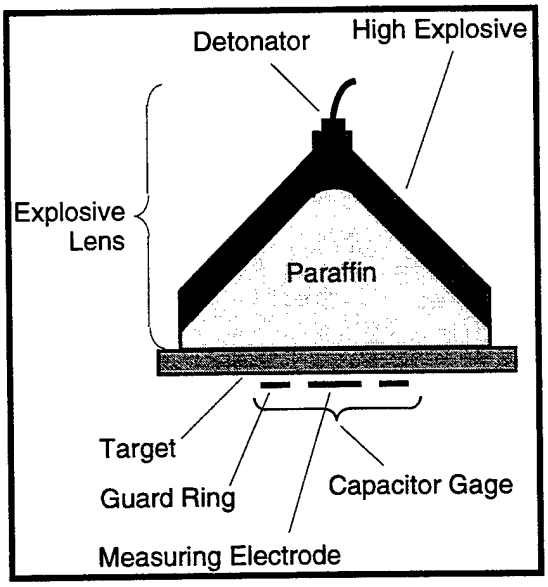
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT6 (sheet) 9.8 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	3.87±0.17 GPa 1.66 mm (±10%)

Reference: Kanel and Petrova (1981)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



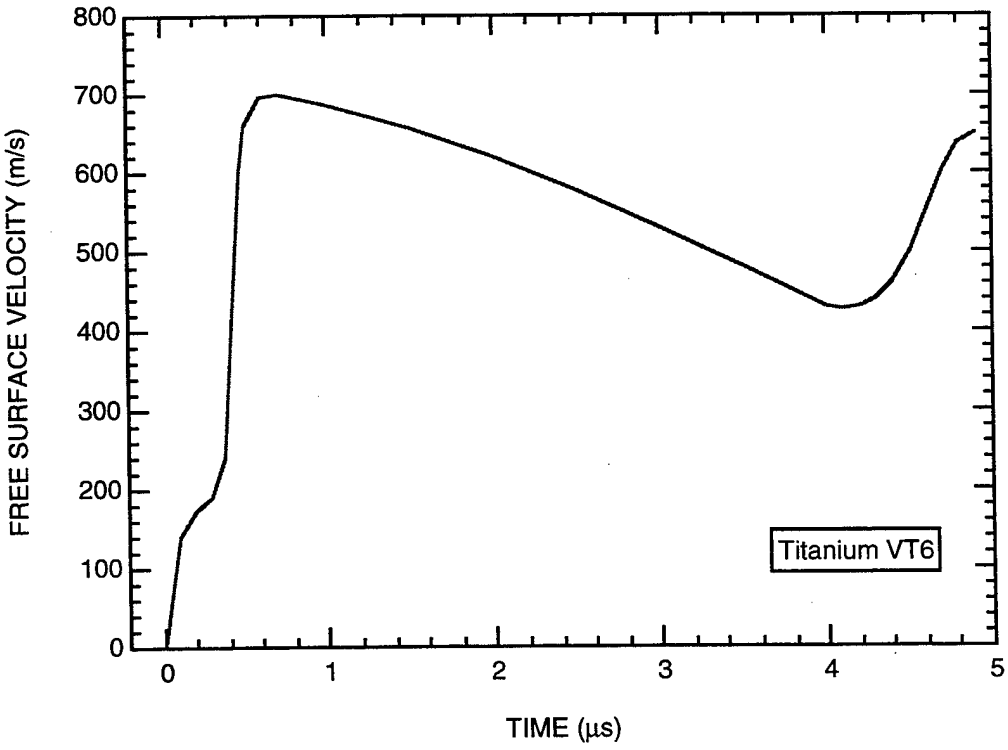
Titanium VT6	
Density	4.43 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



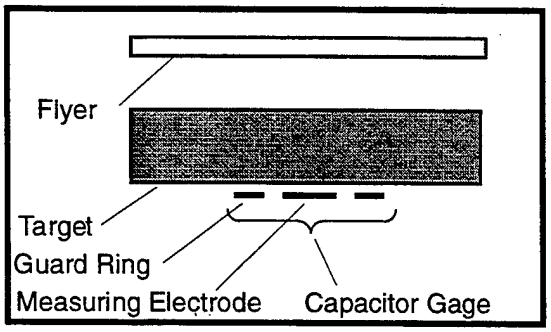
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	Titanium VT6 (sheet) 18.4 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	3.43±0.2 GPa 9.8 mm (±10%)

Reference: Kanel and Petrova (1981)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.

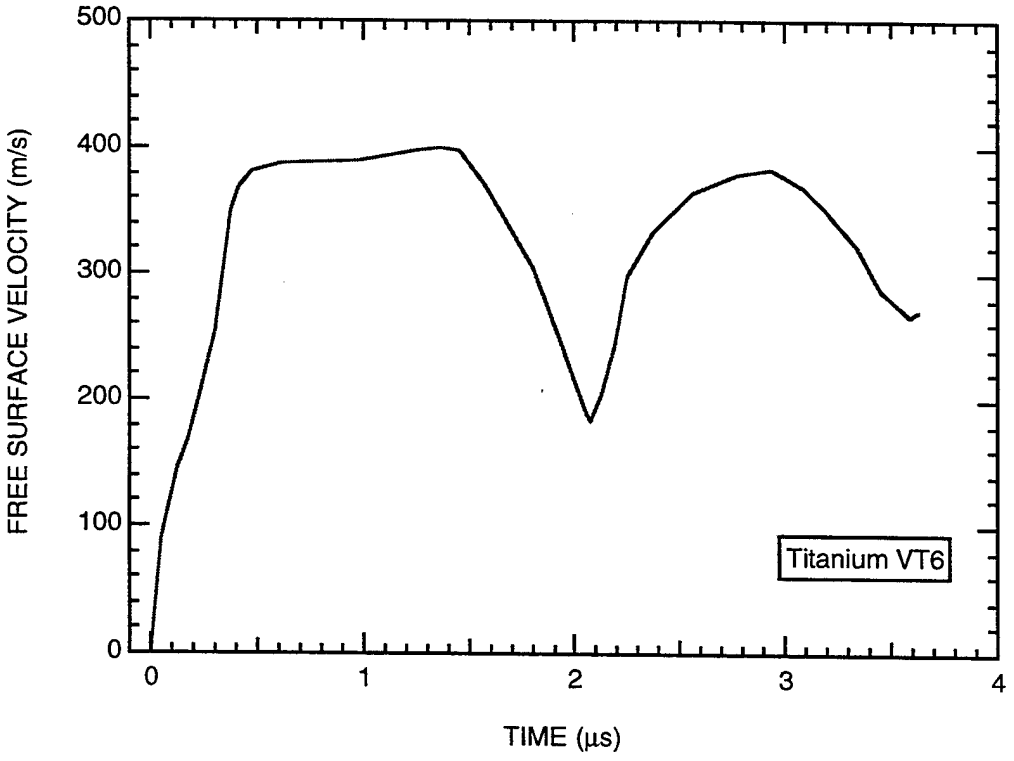


Titanium VT6	
Density	4.43 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



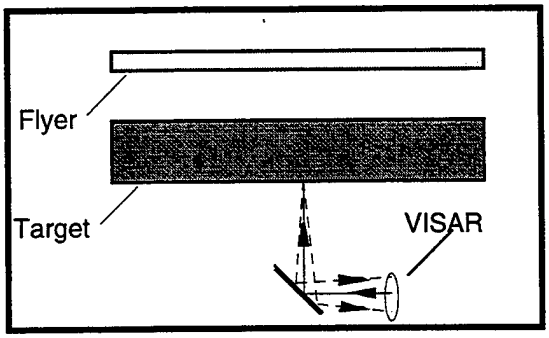
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	600±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Titanium VT6 (sheet) 9.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%

Reference: Kanel and Petrova (1981)



B.13 TITANIUM VT8.

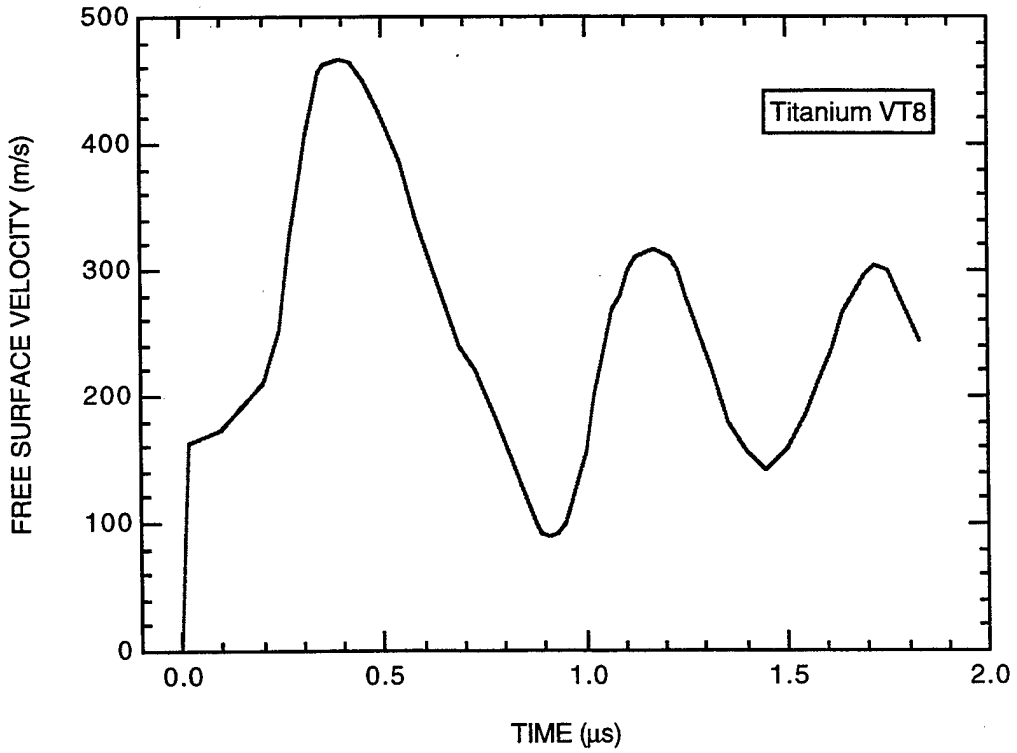
Titanium VT8	
Density	4.45 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



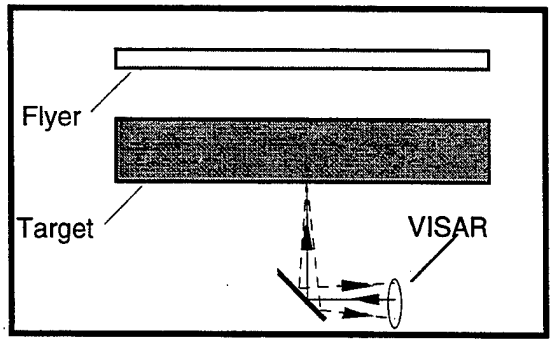
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT8 (rod) 10 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	4.65±0.3 GPa 1.6 mm (±10%)

Reference: Kanel et al. (1987)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



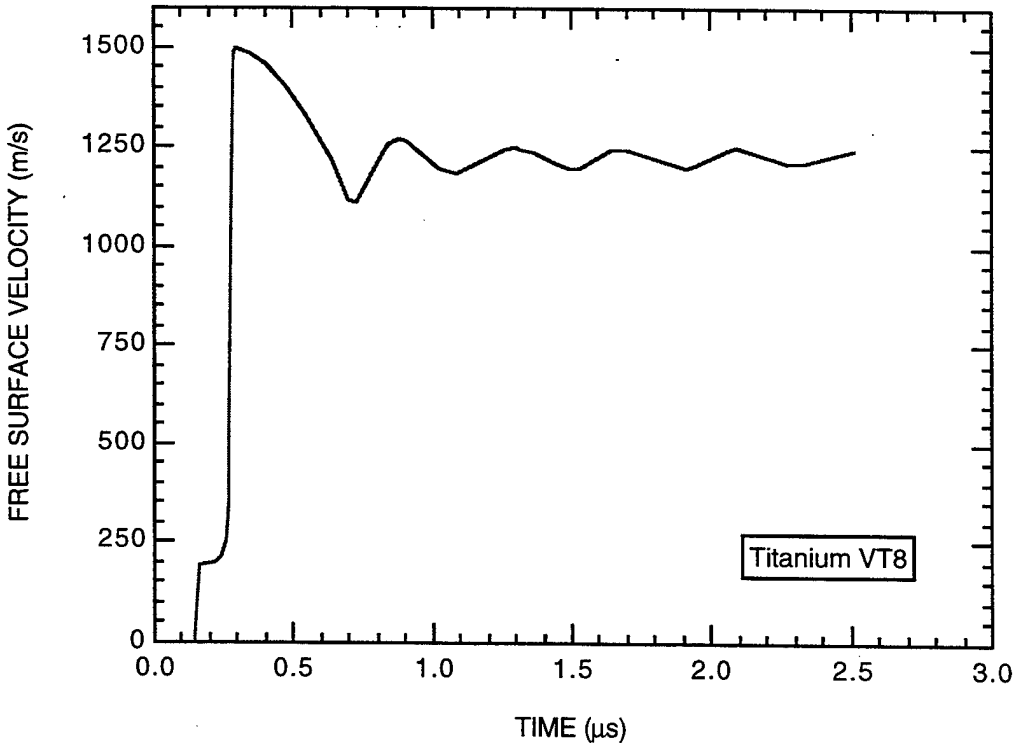
Titanium VT8	
Density	4.45 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



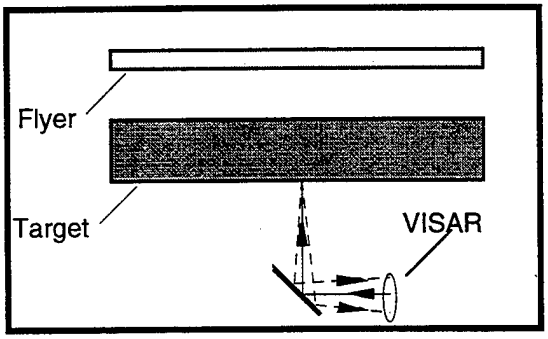
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT8 (rod) 10 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	4.63±0.3 GPa 1.15 mm (±10%)

Reference: Kanel et al. (1987)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



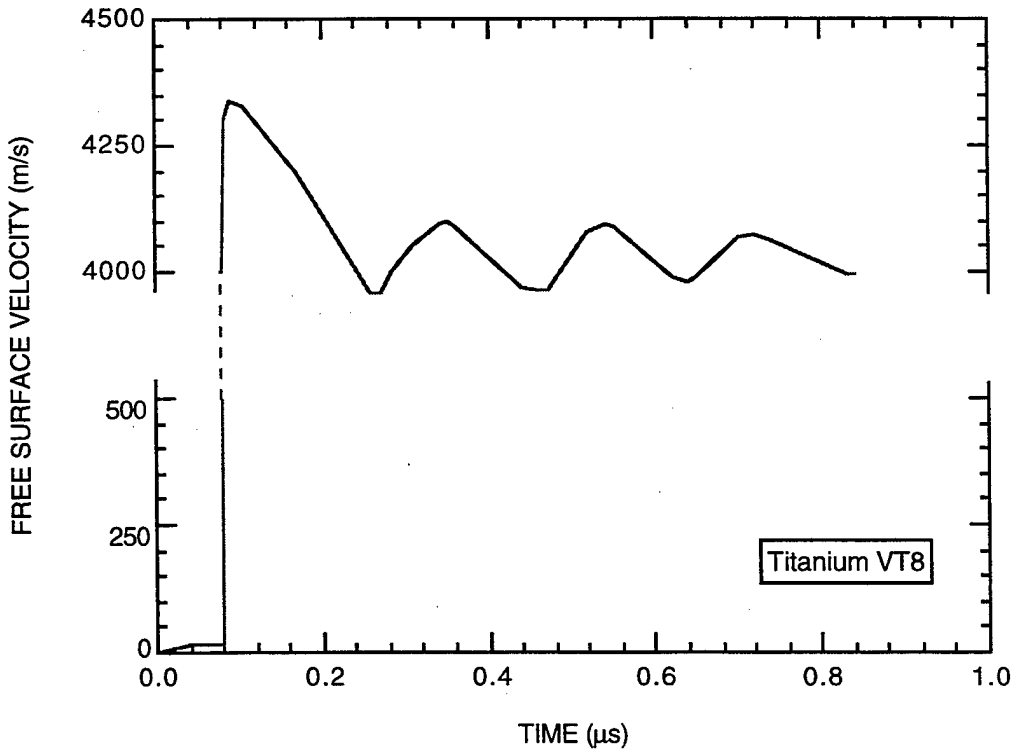
Titanium VT8	
Density	4.45 g/cm^3
Bulk sound velocity	5.11 mm/μs
Longitudinal sound velocity	6.15 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	5300±150 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Titanium VT8 (rod) 10 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	4.63±0.3 GPa 0.52 mm (±10%)

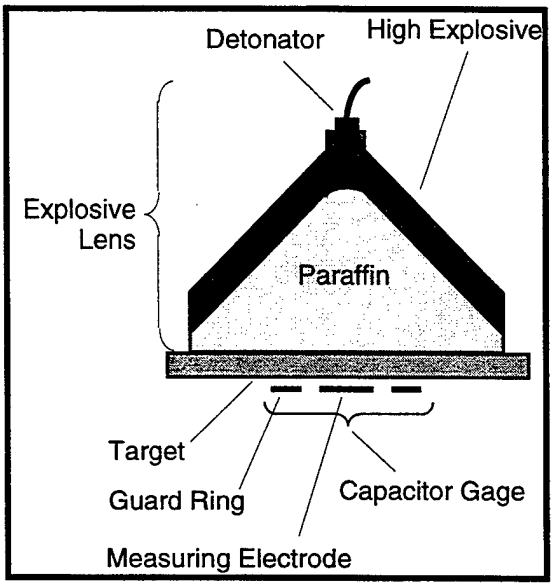
Reference: Kanel et al. (1987)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.14 COPPER M2.

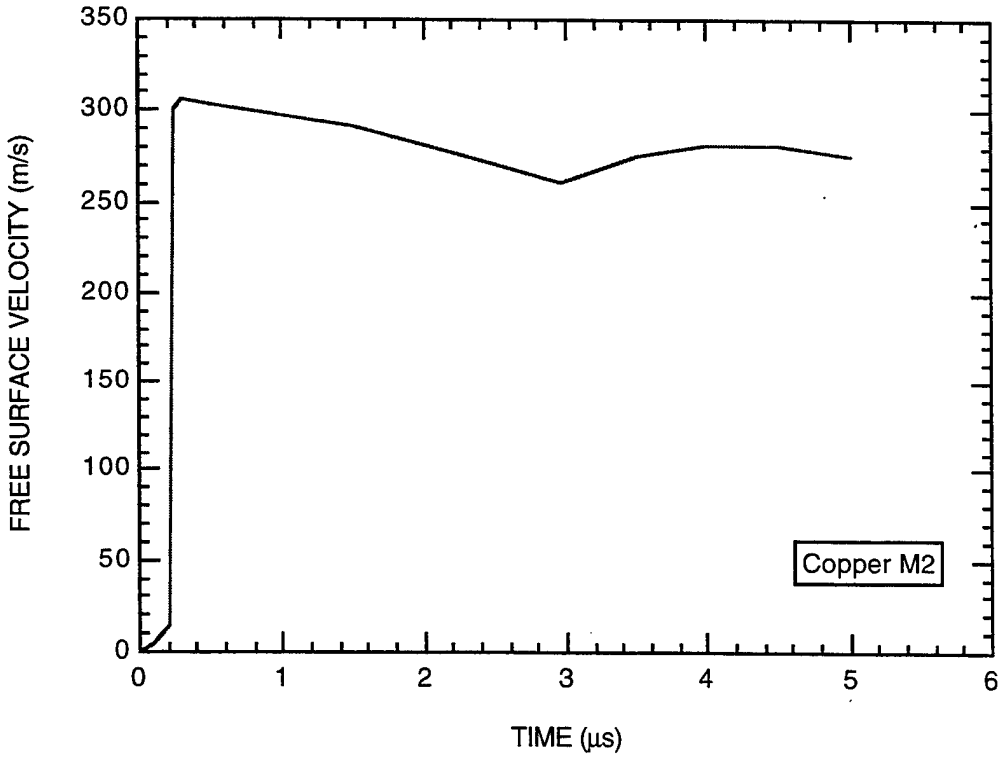
Copper M2	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



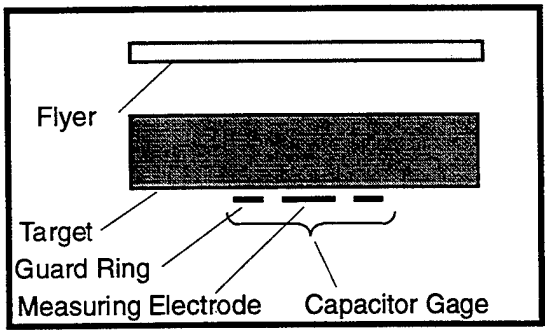
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	Copper M2 (rod) 12.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.8±0.1 GPa 6.0 mm (±10%)

Reference: Razorenov and Kanel (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



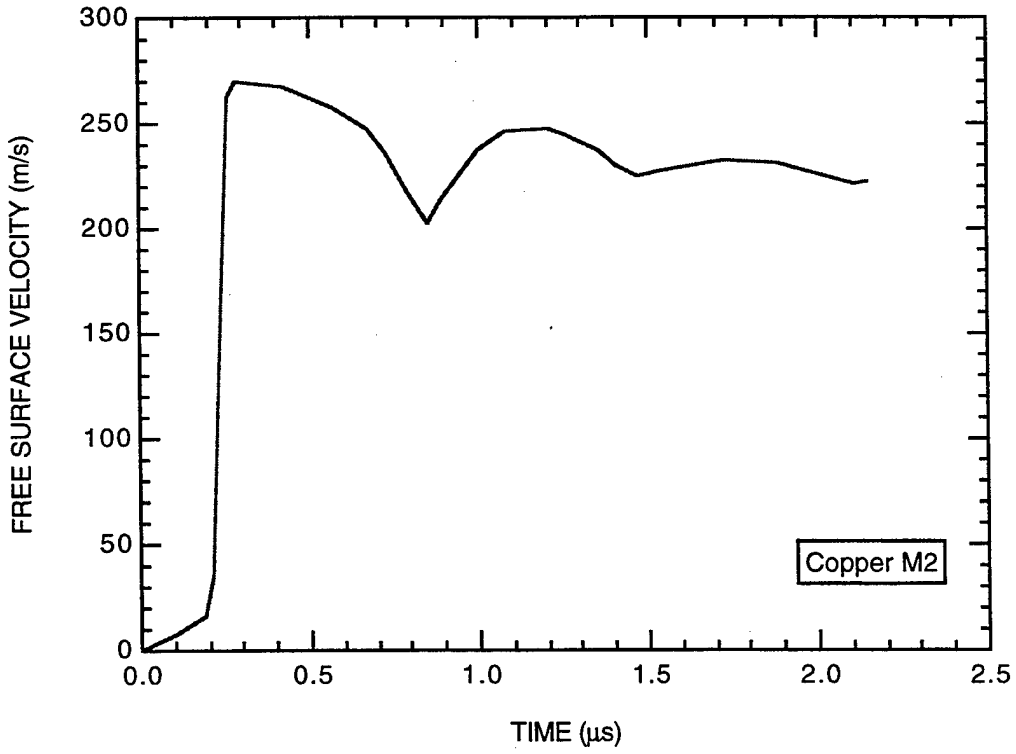
Copper M2	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



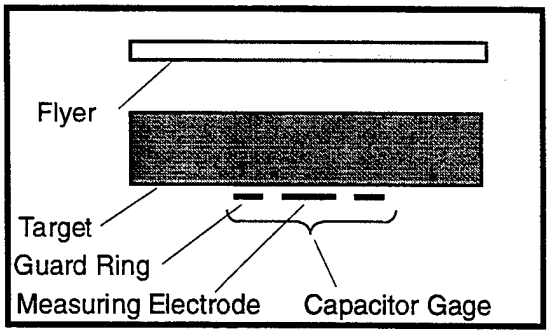
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Copper M2 (rod) 15 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.1±0.1 GPa 1.24 mm (±10%)

Reference: Razorenov and Kanel (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



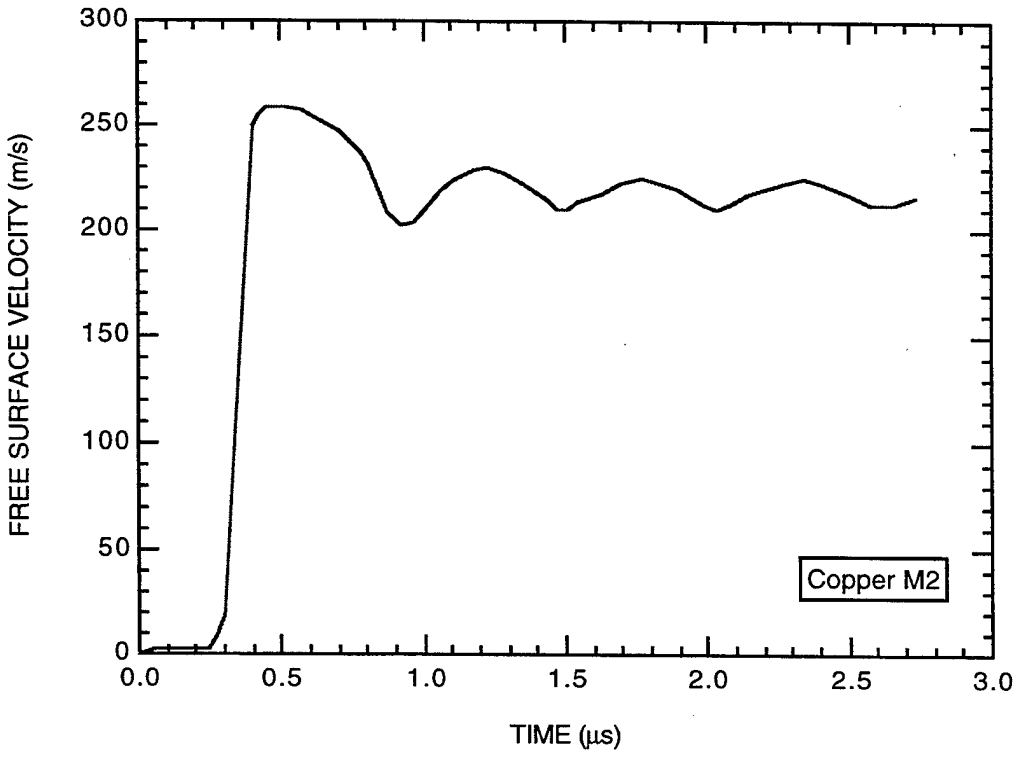
Copper M2	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



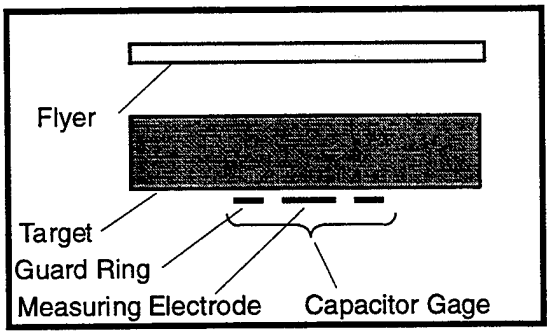
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Copper M2 (rod) 12 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.12±0.1 GPa 1.15 mm (±10%)

Reference: Razorenov and Kanel (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



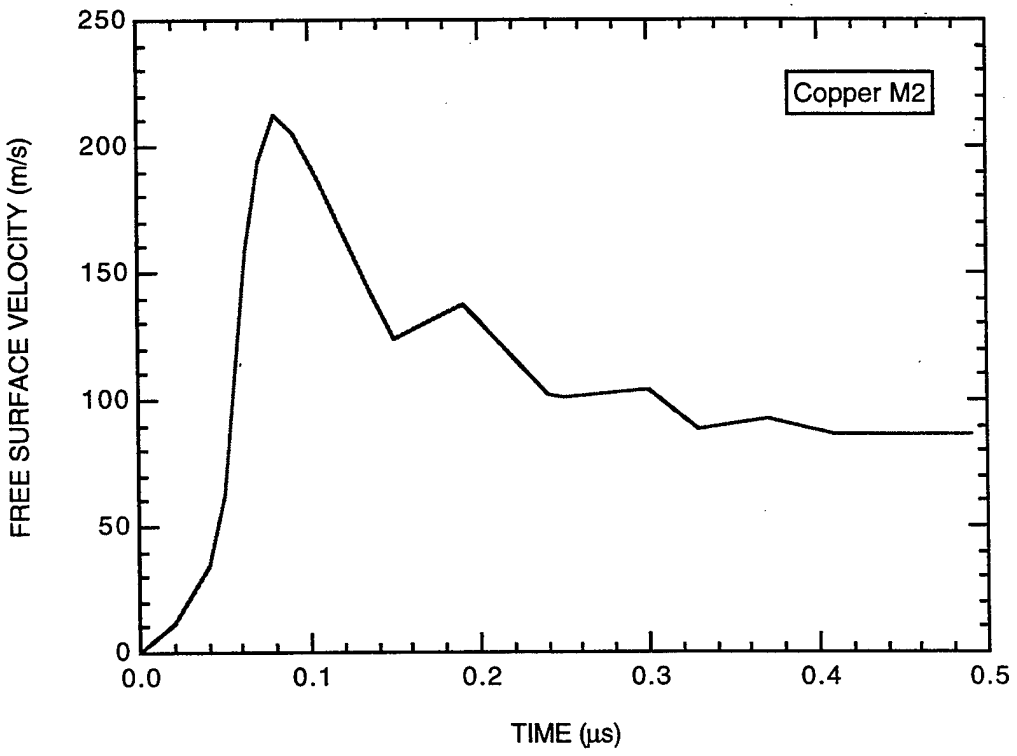
Copper M2	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



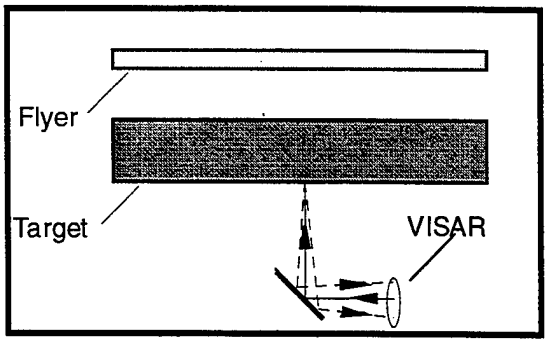
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Copper M2 (rod) 3.9 mm
Measurement technique Electrode diameter	Capacitor gage 5 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.64±0.1 GPa 0.18 mm (±10%)

Reference: Razorenov and Kanel (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



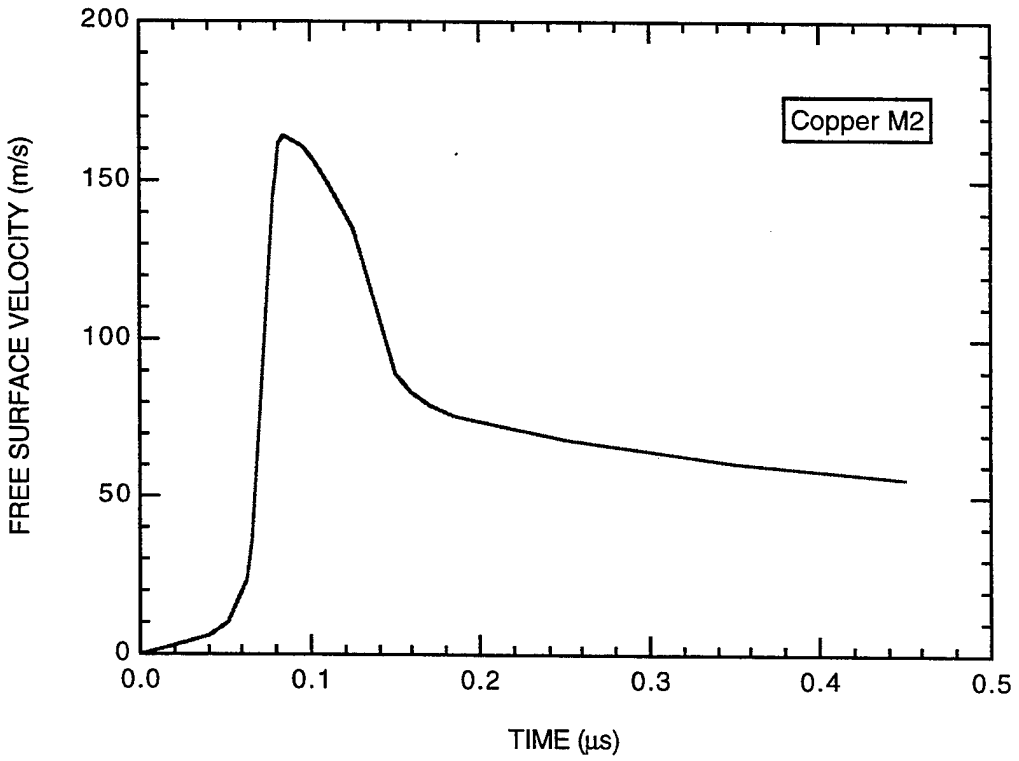
Copper M2	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



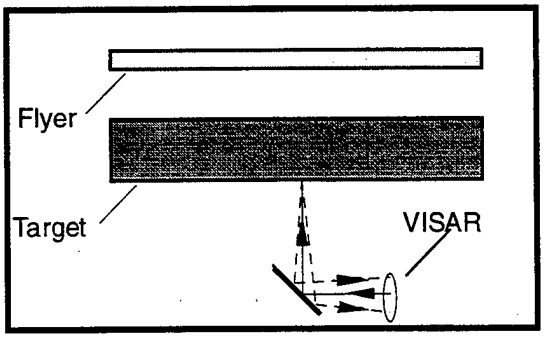
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Copper M2 (rod) 3.9 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	1.5±0.1 GPa 0.18 mm(±10%)

Reference: Razorenov and Kanel (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



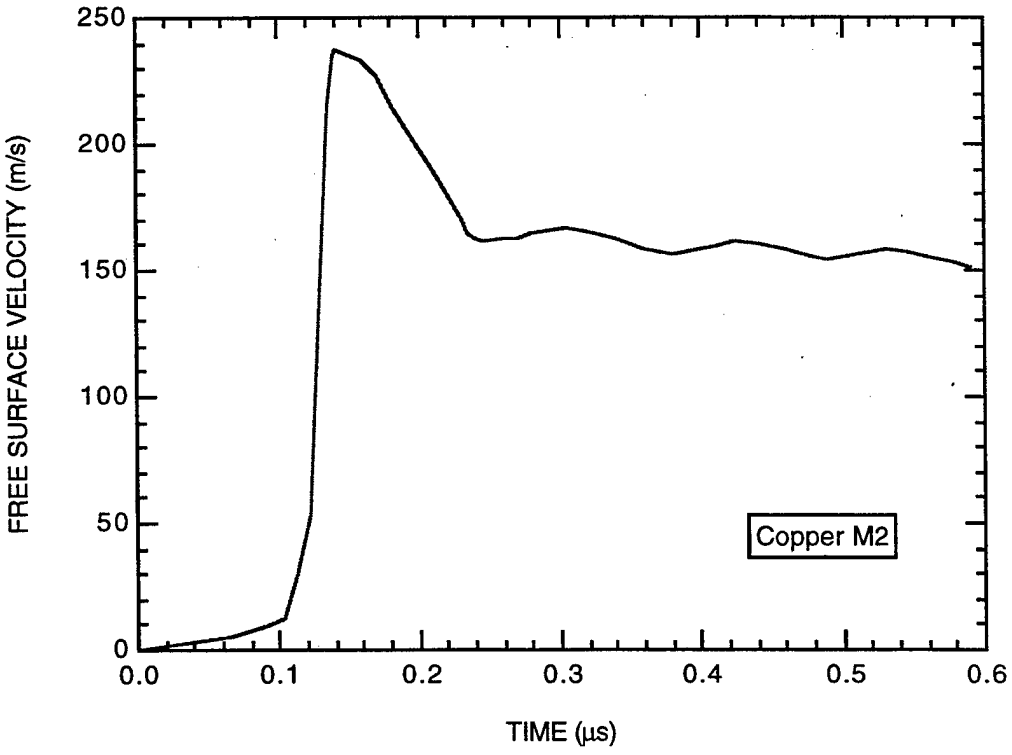
Copper M2	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Copper M2 (rod) 2.7 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	1.35±0.1 GPa 0.23 mm (±10%)

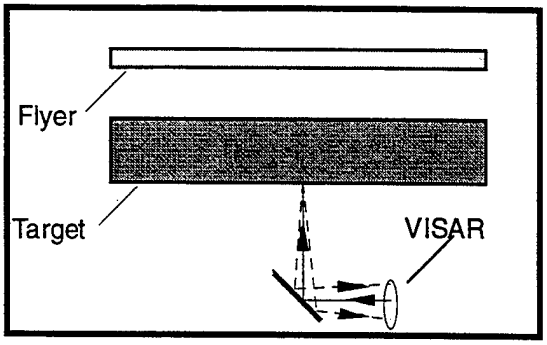
Reference: Razorenov and Kanel (1992)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.15 COPPER SINGLE CRYSTAL.

Copper Single Crystal	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs

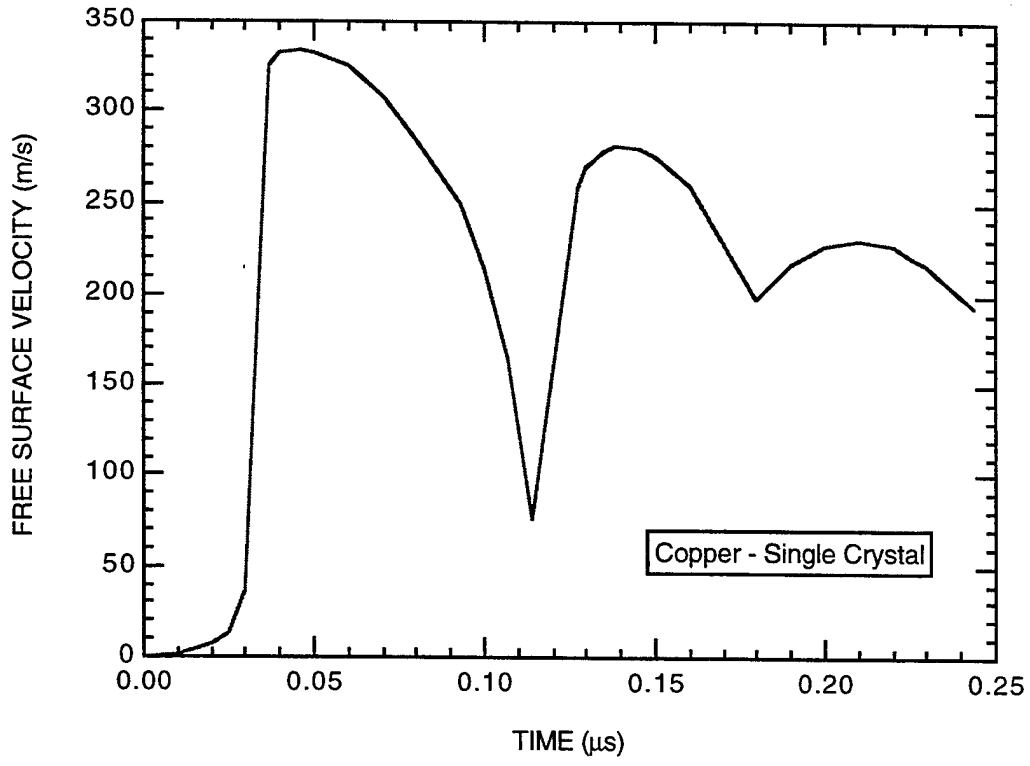


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Copper single crystal[1] 0.7 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	4.5±0.1 GPa 0.14 mm (±10%)

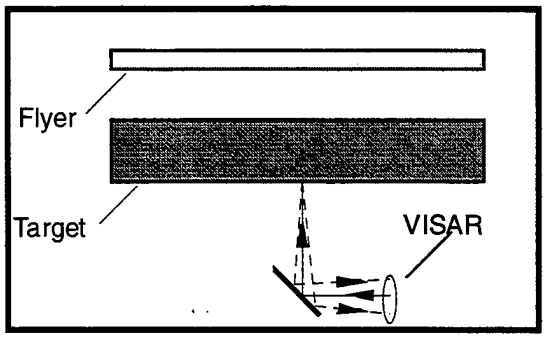
Reference: Razorenov and Kanel (1992)

[1] Loaded in direction <111>

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



Copper Single Crystal	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs

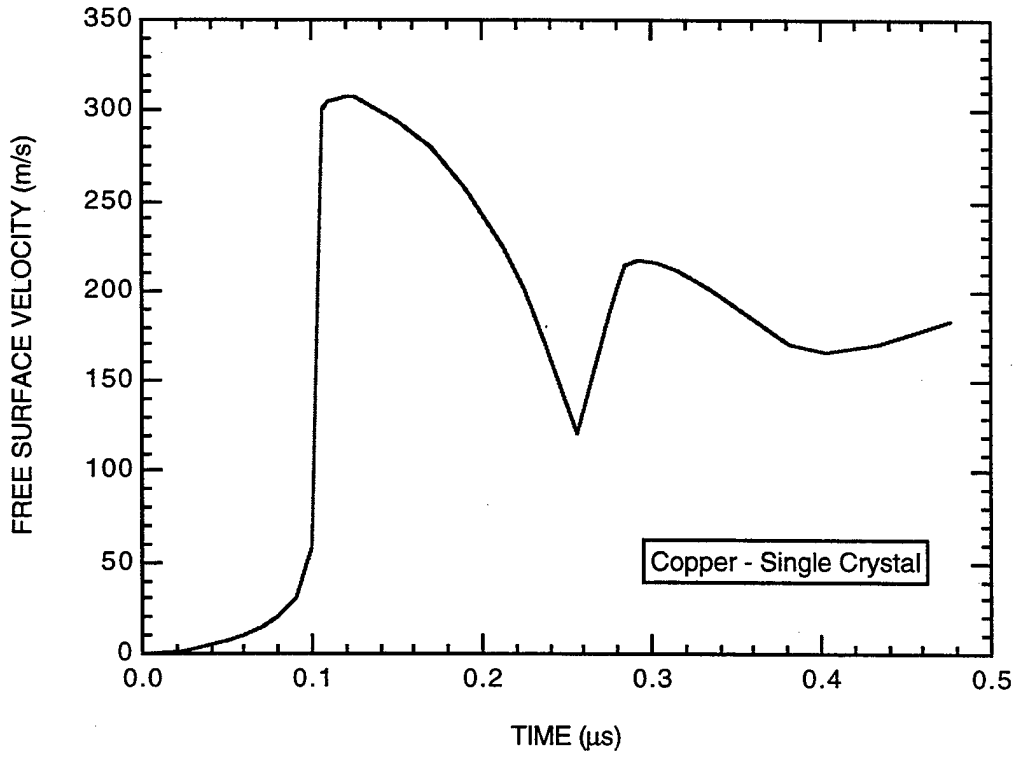


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Copper single crystal[1] 1.9 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.45±0.2 GPa 0.33 mm (±10%)

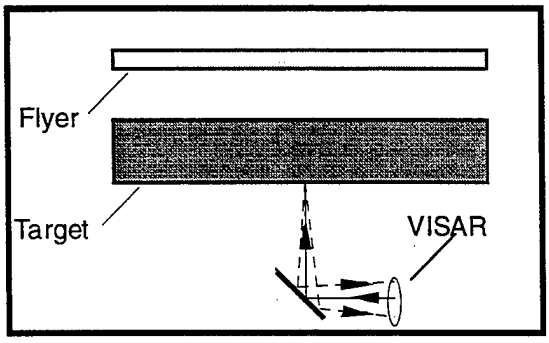
Reference: Razorenov and Kanel (1992)

[1] Loaded in direction <111>

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



Copper Single Crystal	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs

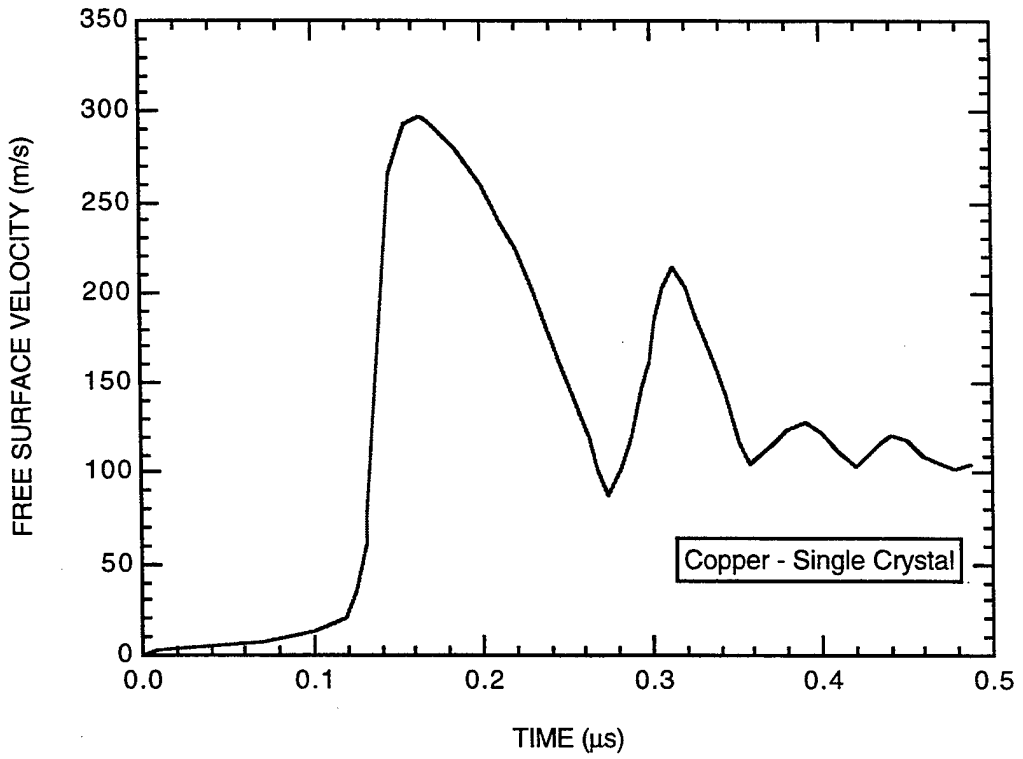


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Copper single crystal[1] 1.95 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.75±0.2 GPa 0.25 mm (±10%)

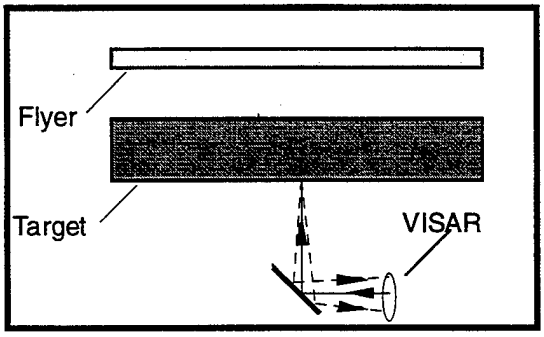
Reference: Razorenov and Kanel (1992)

[1] Loaded in direction <111>

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



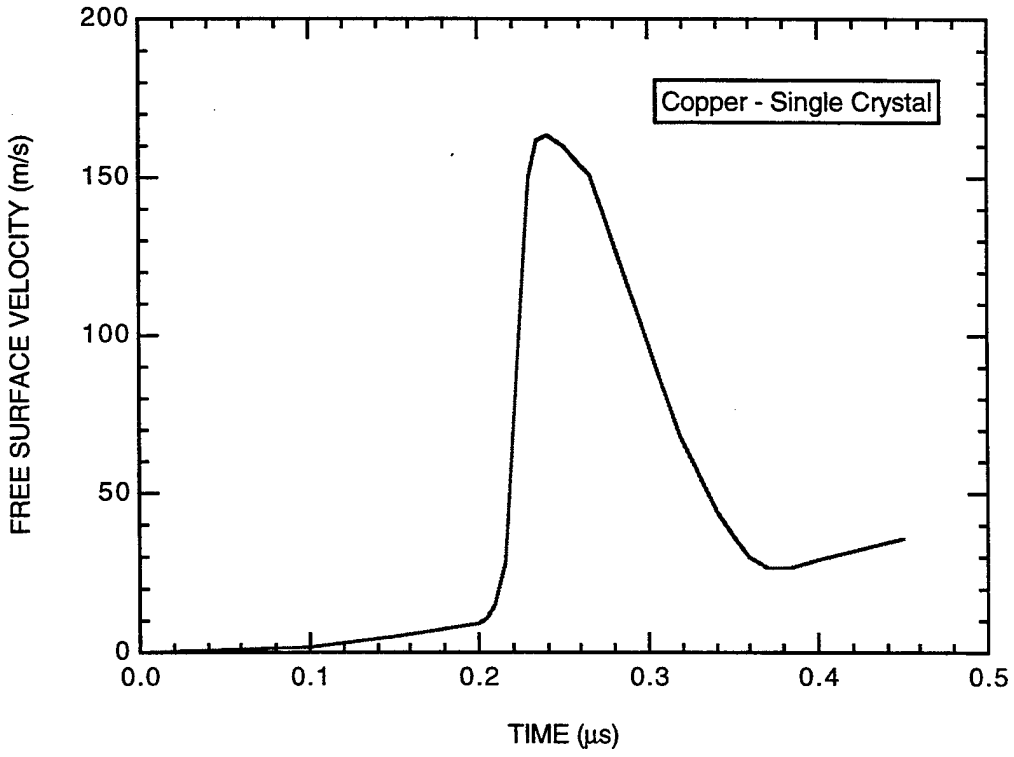
Copper Single Crystal	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs



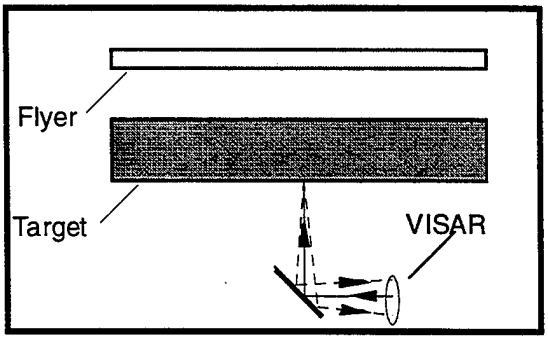
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Copper single crystal[1] 4.35 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Peak tensile stress	No spall 2.5±0.1 GPa

Reference: Razorenov and Kanel (1992)

[1] Loaded in direction <111>



Copper Single Crystal	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs

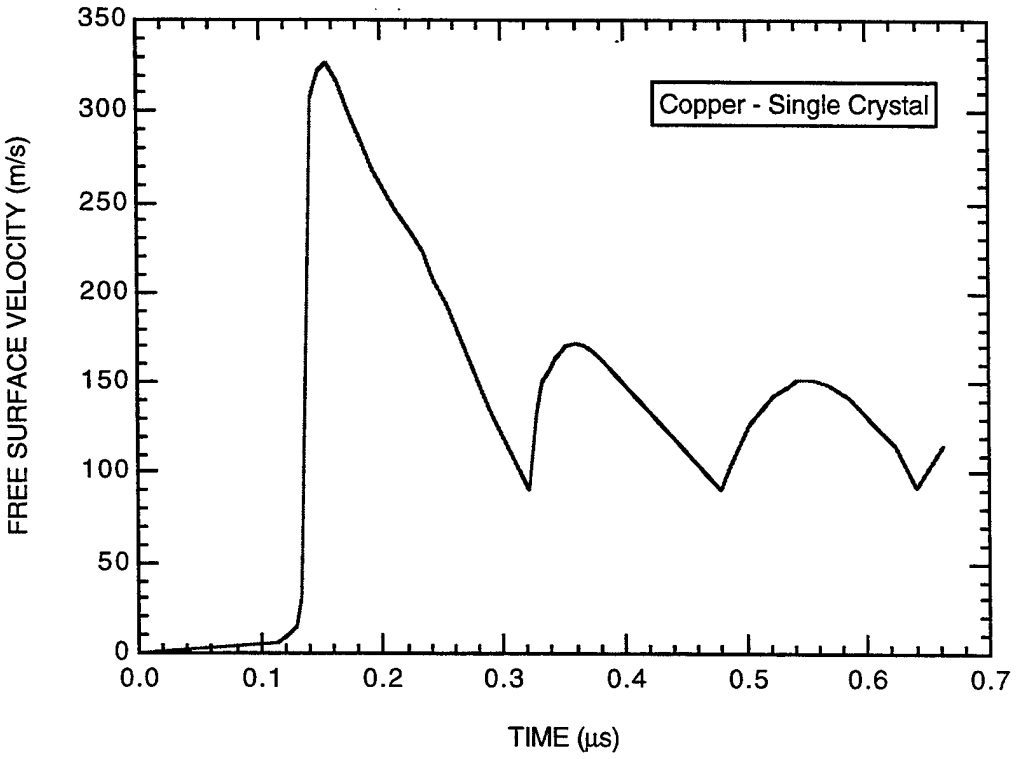


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Copper single crystal[1] 4.3 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	4.5±0.1 GPa 0.33 mm (±10%)

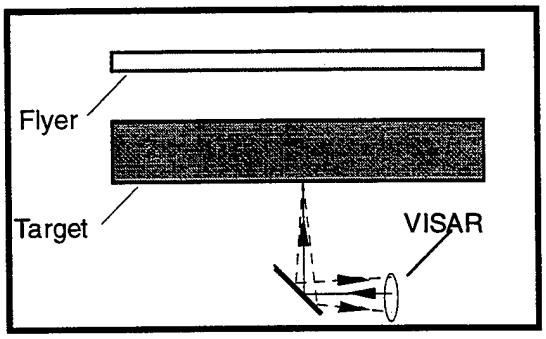
Reference: Razorenov and Kanel (1992)

[1] Loaded in direction <100>

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



Copper Single Crystal	
Density	8.93 g/cm^3
Bulk sound velocity	3.96 mm/μs
Longitudinal sound velocity	4.6 mm/μs

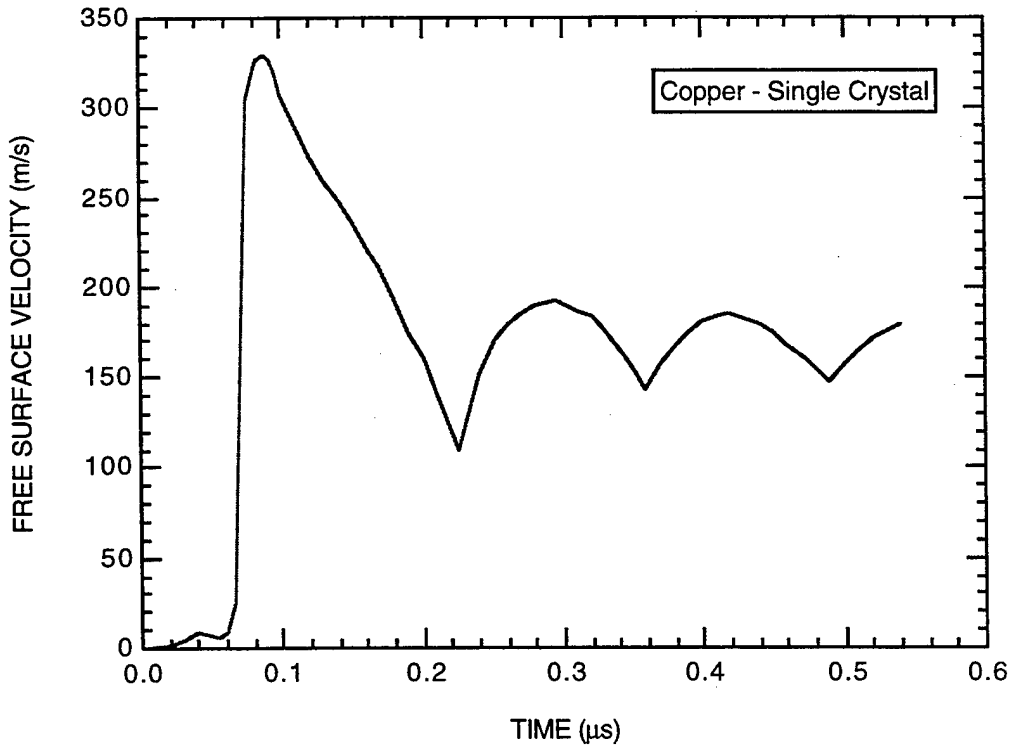


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Copper single crystal[1] 4.5 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.95±0.1 GPa 0.3 mm (±10%)

Reference: Razorenov and Kanel (1992)

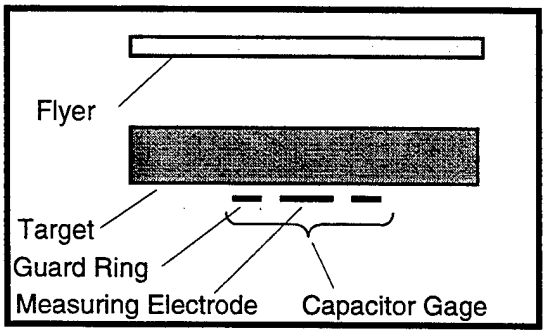
[1] - Annealed for 2 hours at 900°C.
- Loaded in direction <100>.

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



B.16 NICKEL NP-2.

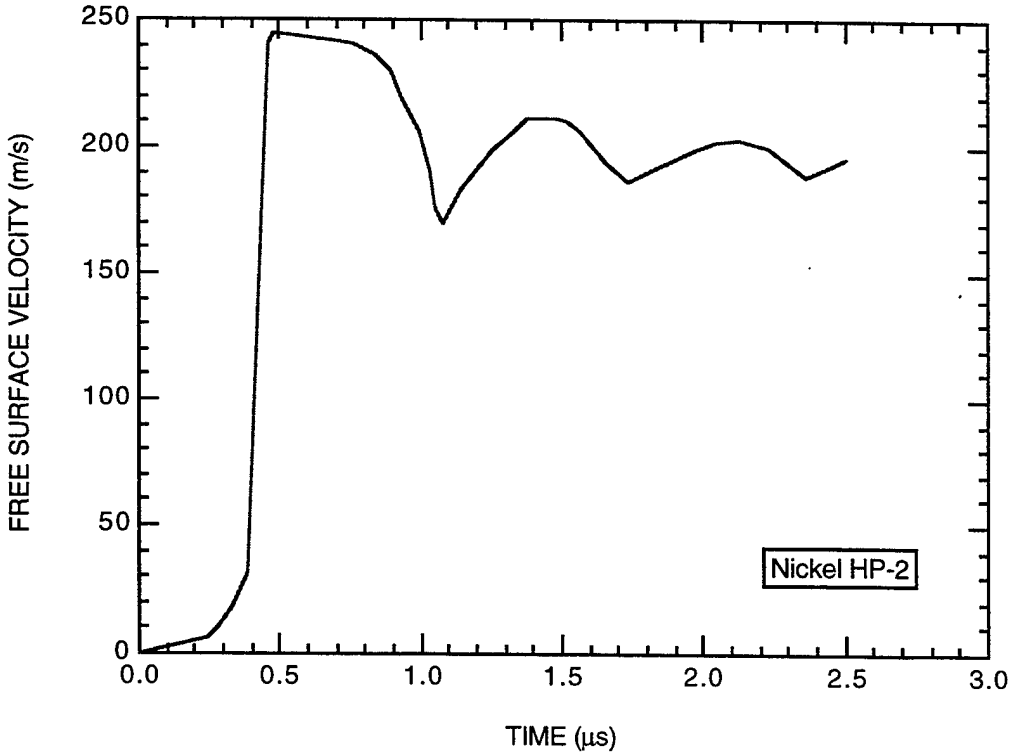
Nickel NP-2	
Density	8.86 g/cm^3
Bulk sound velocity	4.57 mm/μs
Longitudinal sound velocity	5.63 mm/μs



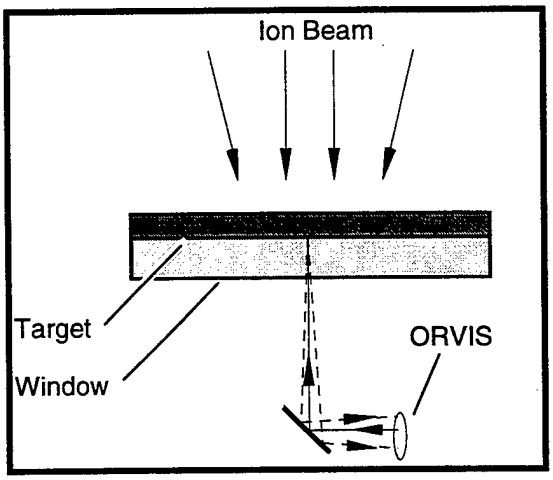
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	445±15 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Nickel NP-2 (rod) 9.5 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.49±0.08 GPa 1.46 mm (±10%)

Reference: Kanel (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



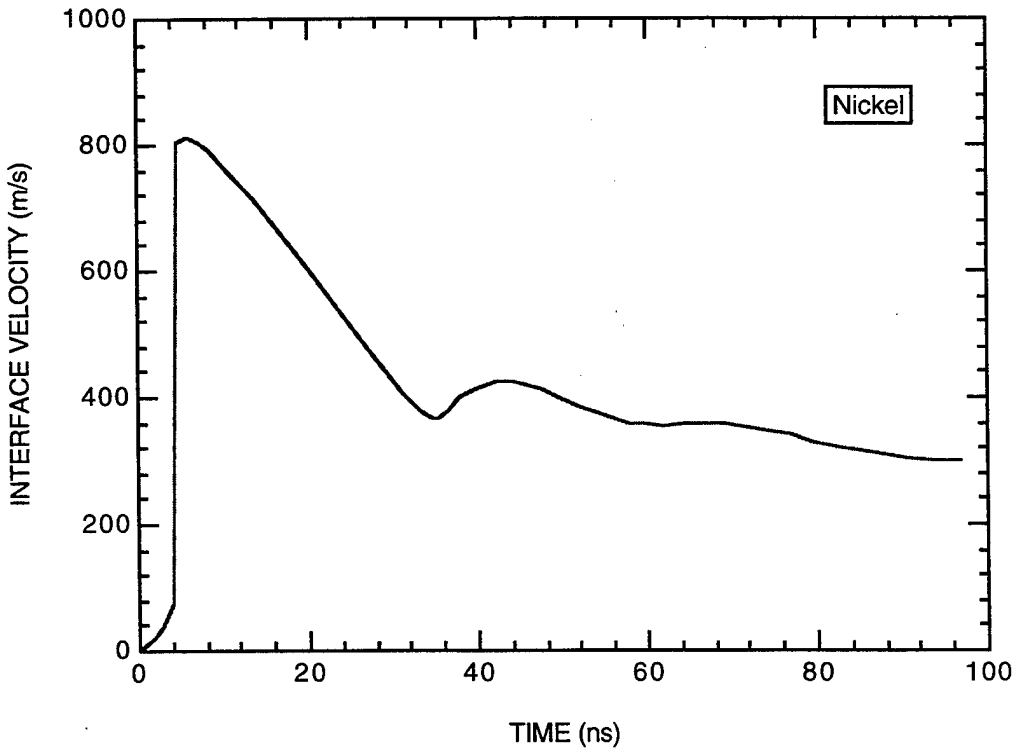
Nickel	
Density	8.86 g/cm^3
Bulk sound velocity	4.57 mm/μs
Longitudinal sound velocity	5.63 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Nickel (sheet) 0.4mm
Measurement technique[1]	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	6.3±0.3 GPa 0.08 mm (±10%)

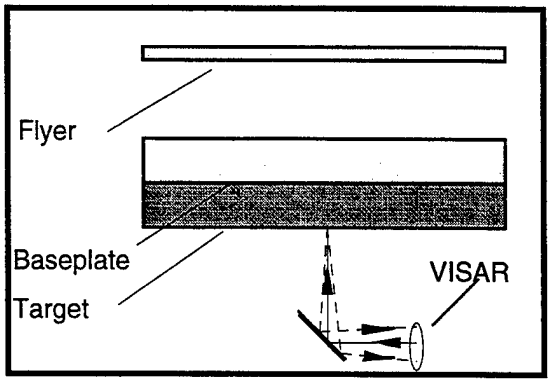
[1] measurement through water window.

[2] Determined based on the period of oscillation in the measured free-surface velocity history.



B.17 MOLYBDENUM POLYCRYSTAL.

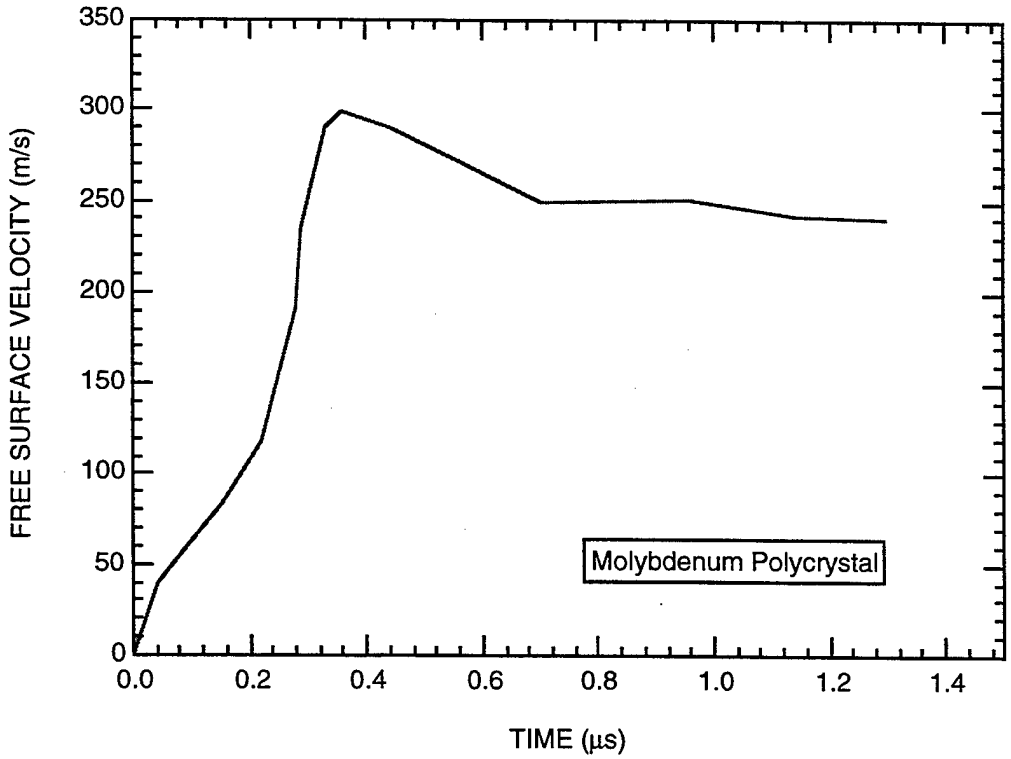
Molybdenum Polycrystal (Sintered Rod)	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



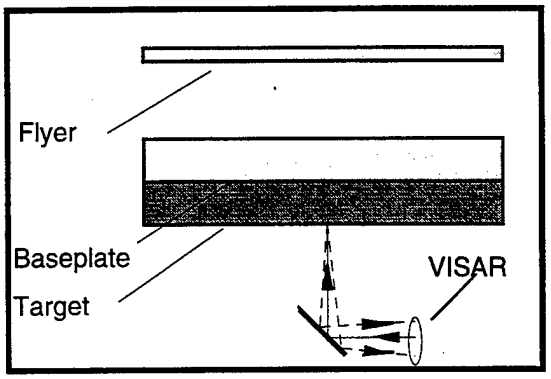
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4.9 mm
Target: - material - thickness	Molybdenum polycrystal 5.9 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	1.32±0.05 GPa 1.13 mm (±10%)

Reference: Kanel et al. (1993)

[1] Determined based on the period of oscillation in the measured velocity history.



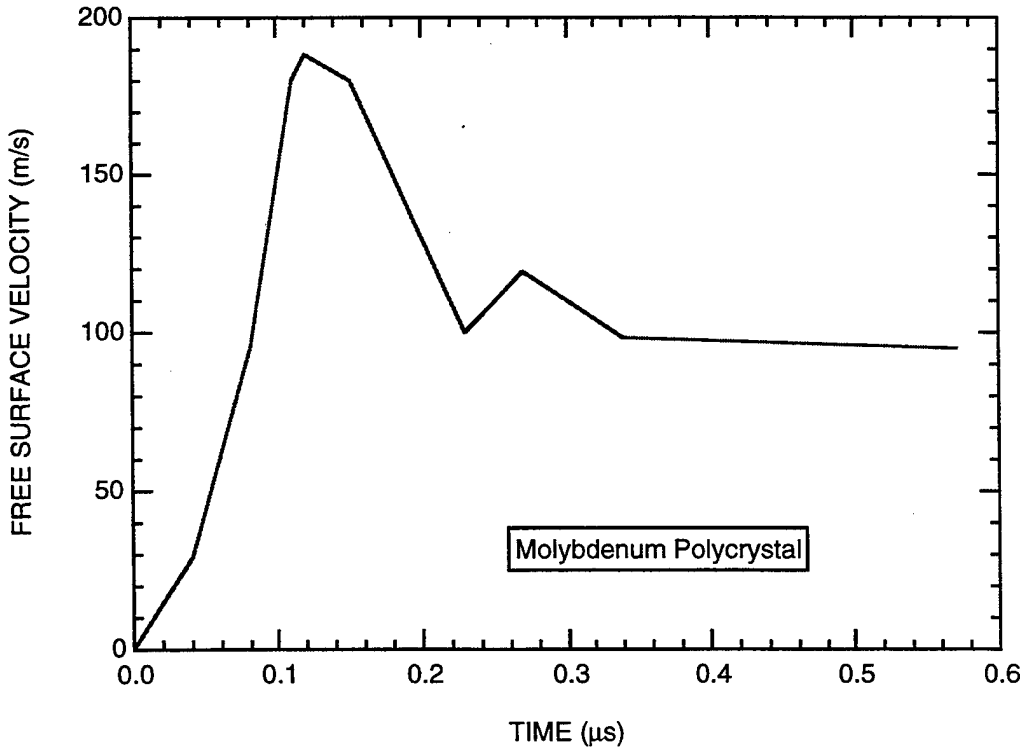
Molybdenum Polycrystal (Sintered Rod)	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



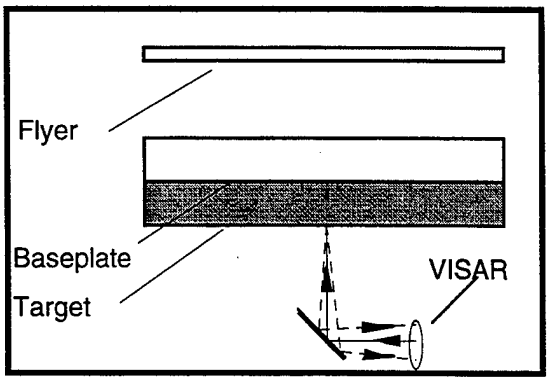
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum polycrystal 2.07 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	2.4±0.05 GPa 0.4 mm (±10%)

Reference: Kanel et al. (1993)

[1] Determined based on the period of oscillation in the measured velocity history.



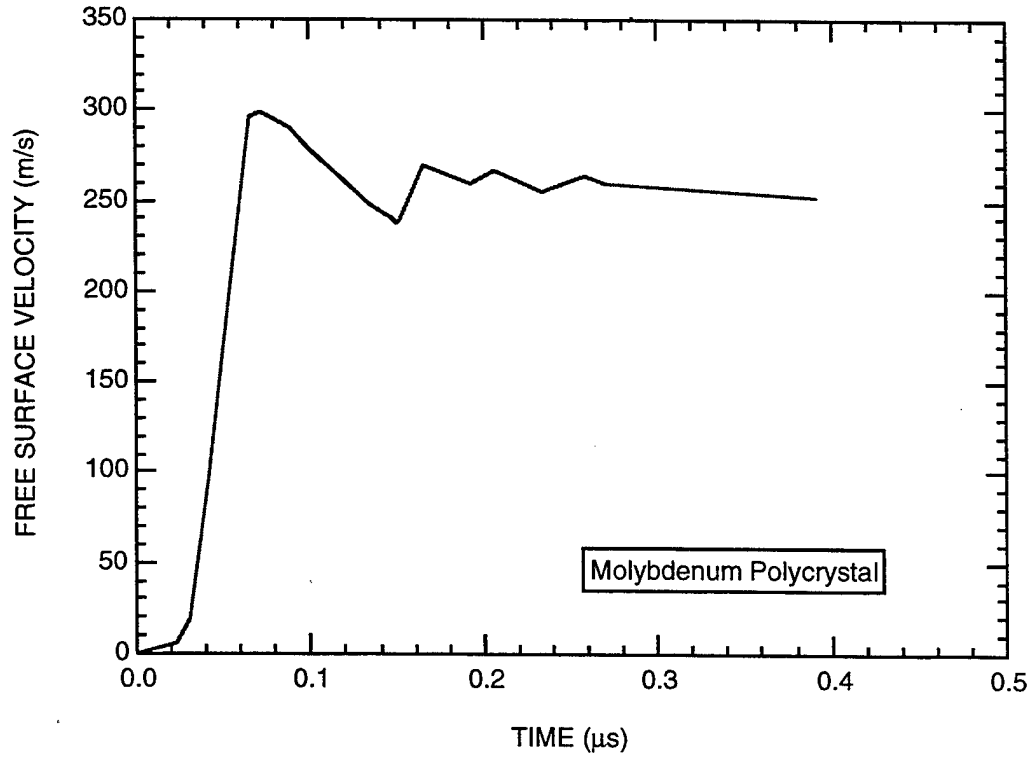
Molybdenum Polycrystal (Sintered Rod)	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum polycrystal 0.75 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	1.8±0.05 GPa 0.26 mm (±10%)

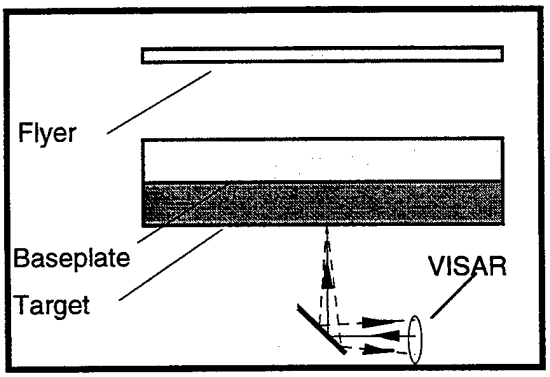
Reference: Kanel et al. (1993)

[1] Determined based on the period of oscillation in the measured velocity history.



B.18 MOLYBDENUM SINGLE CRYSTAL, <100>.

Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

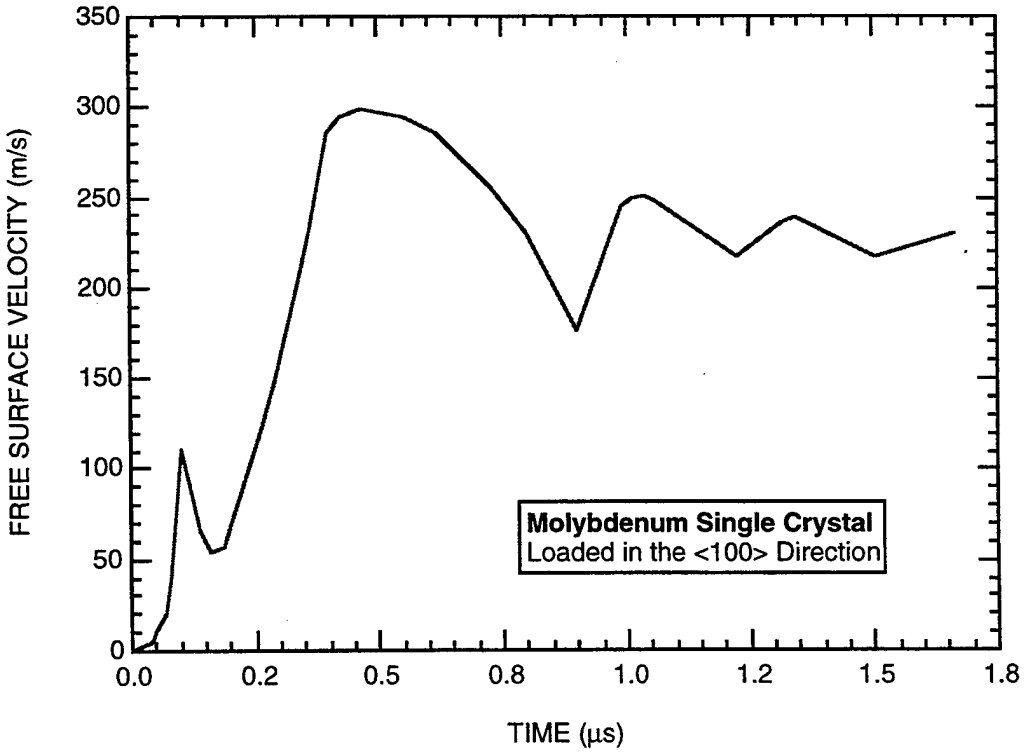


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4.0 mm
Target: - material - thickness	Molybdenum[1] 3.88 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.3±0.2 GPa 1.05 mm (±10%)

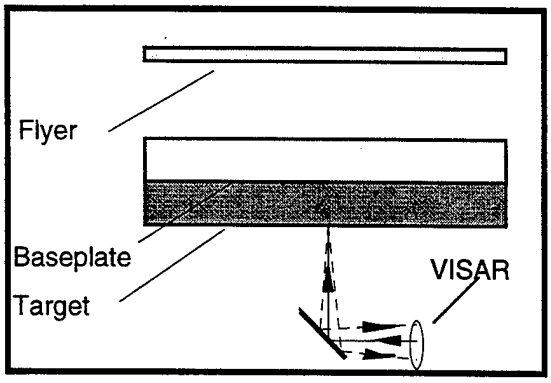
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

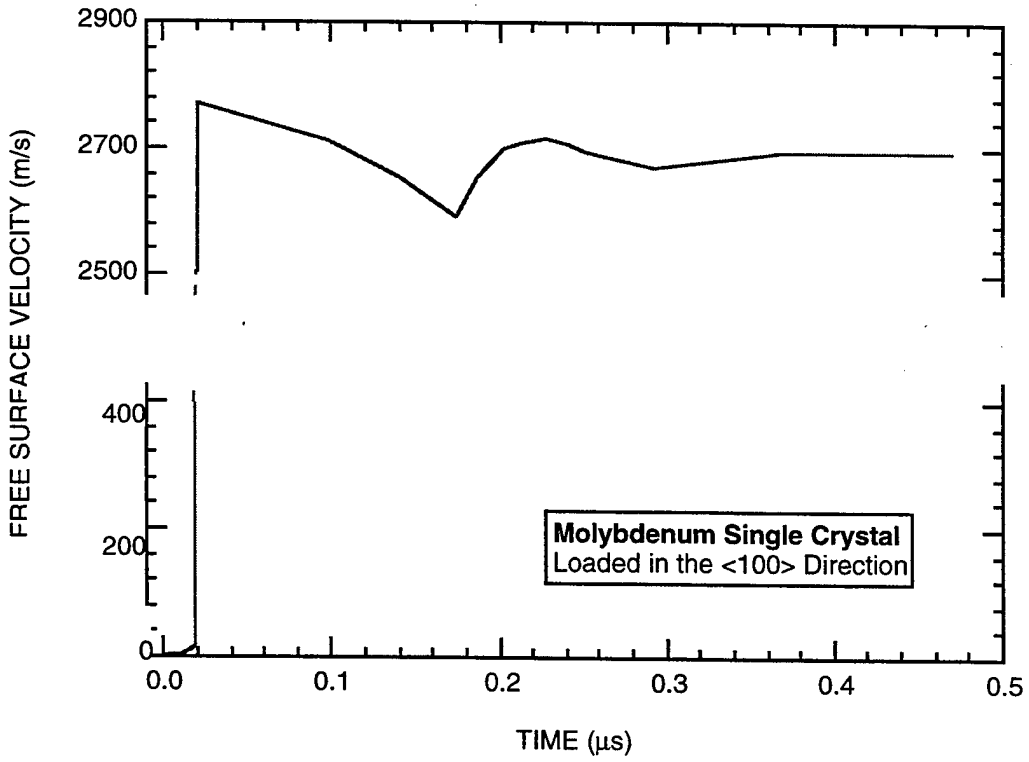


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	5300±150 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 5.0 mm
Target: - material - thickness	Molybdenum[1] 4.6 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	4.85±0.2 GPa 1.3 mm (±10%)

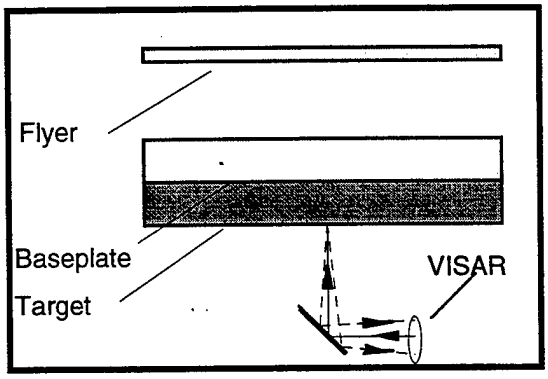
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

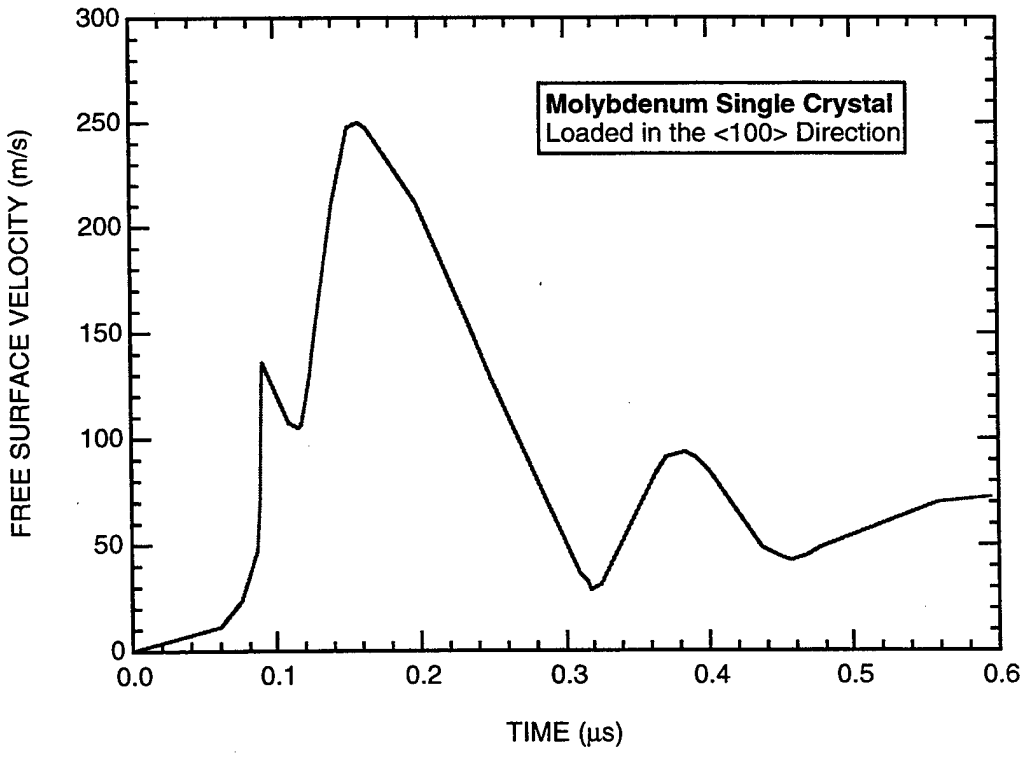


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum[1] 1.4 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	5.6±0.05 GPa 0.43 mm (±10%)

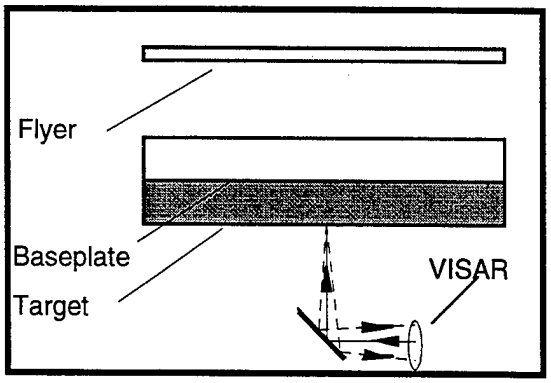
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

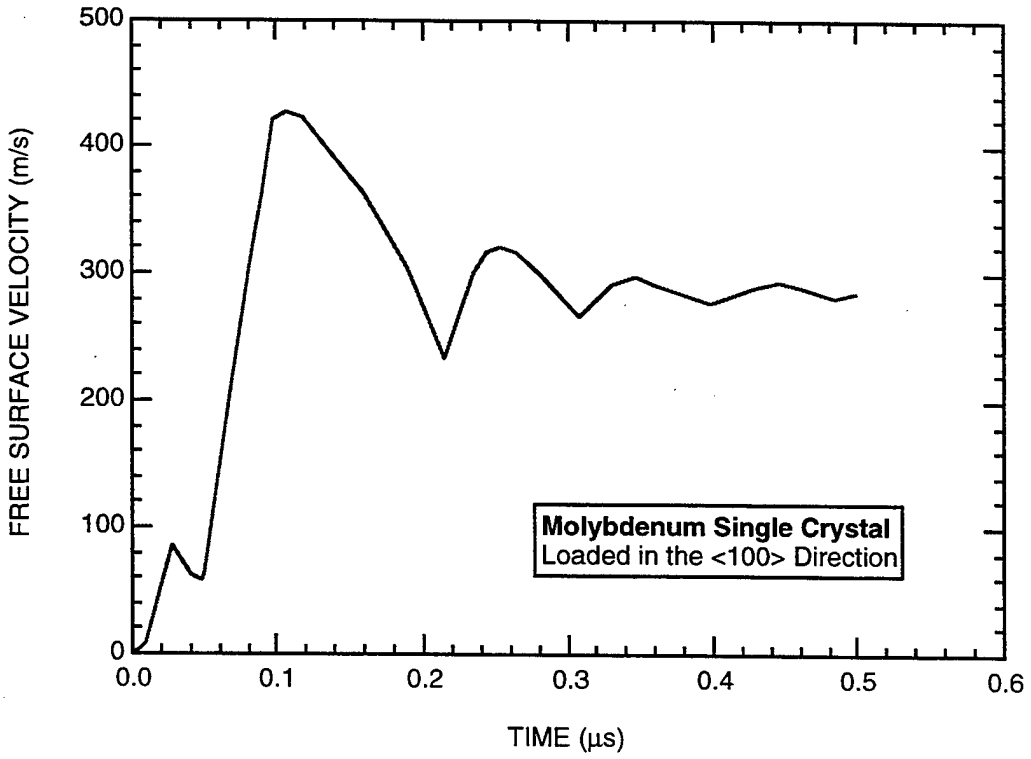


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1250±50 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum[1] 1.38 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	5.4±0.2 GPa 0.29 mm (±10%)

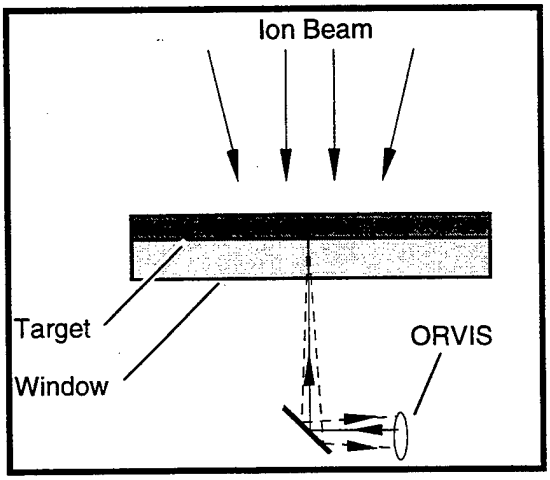
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

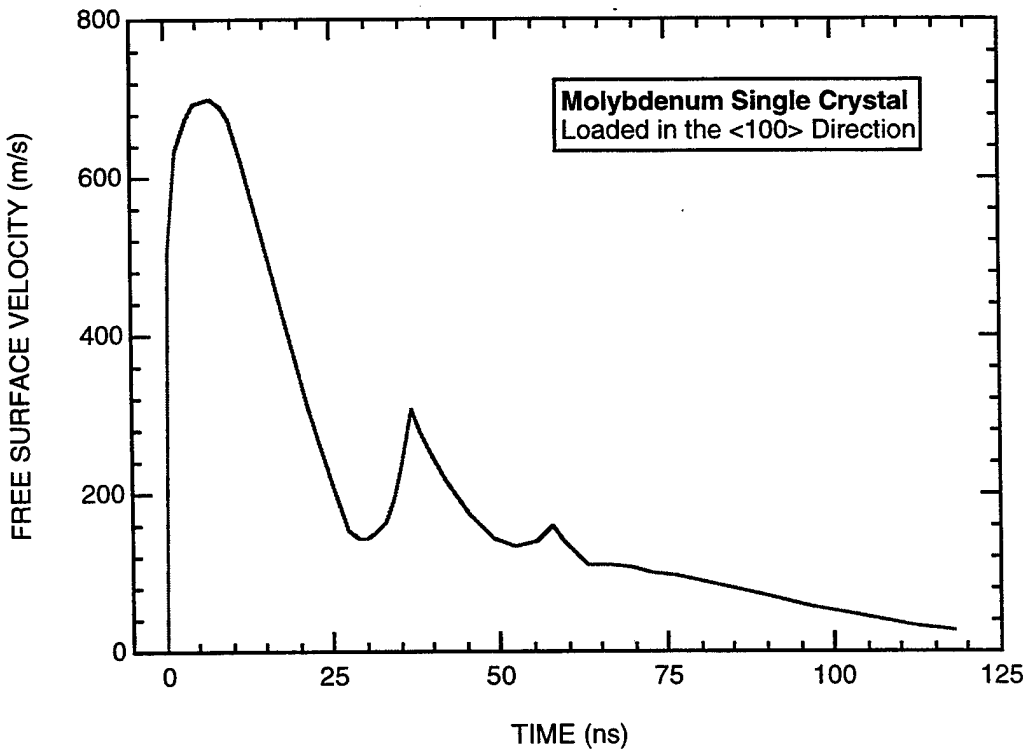


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Molybdenum[1] 0.32 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	13.5±0.1 GPa 0.07 mm (±10%)

Reference: Kanel et al. (1993)

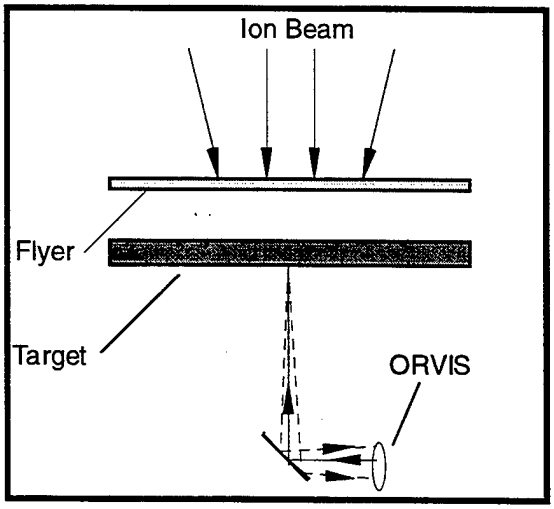
[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



B.19 MOLYBDENUM SINGLE CRYSTAL, <100> DEFORMED.

Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

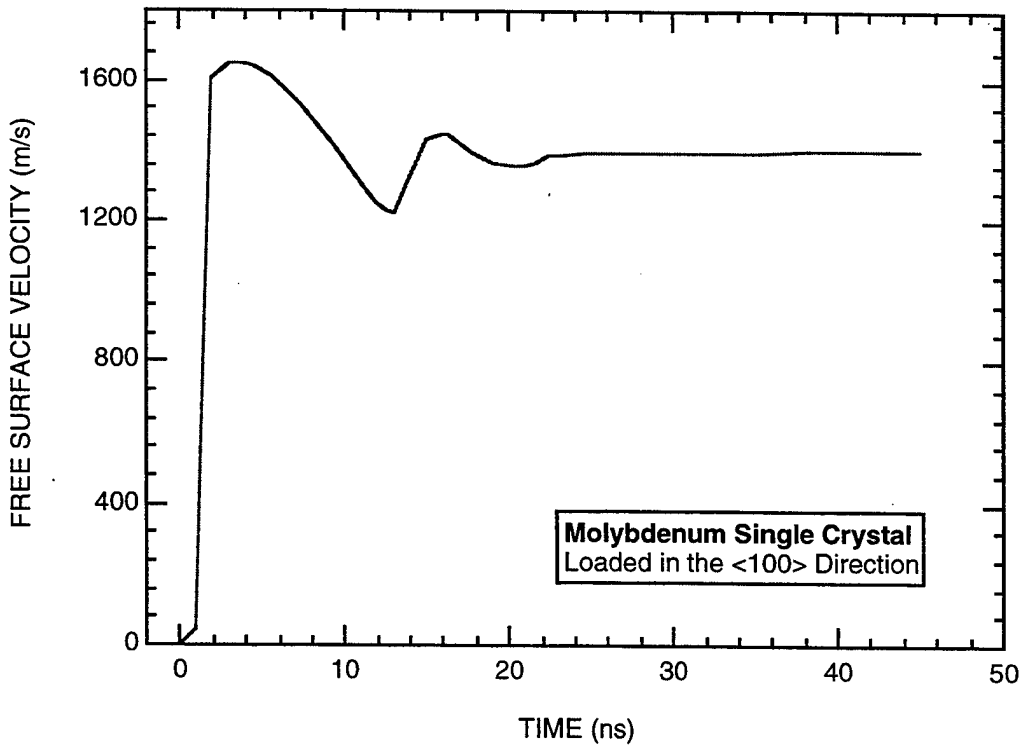


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Molybdenum[1] 0.275 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	11.5±0.2 GPa 0.022 mm (±10)

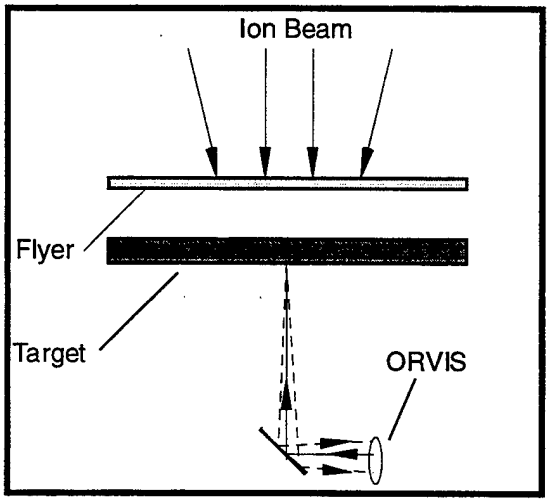
Reference: Kanel et al. (1993)

[1] Deformed (90% to 95%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

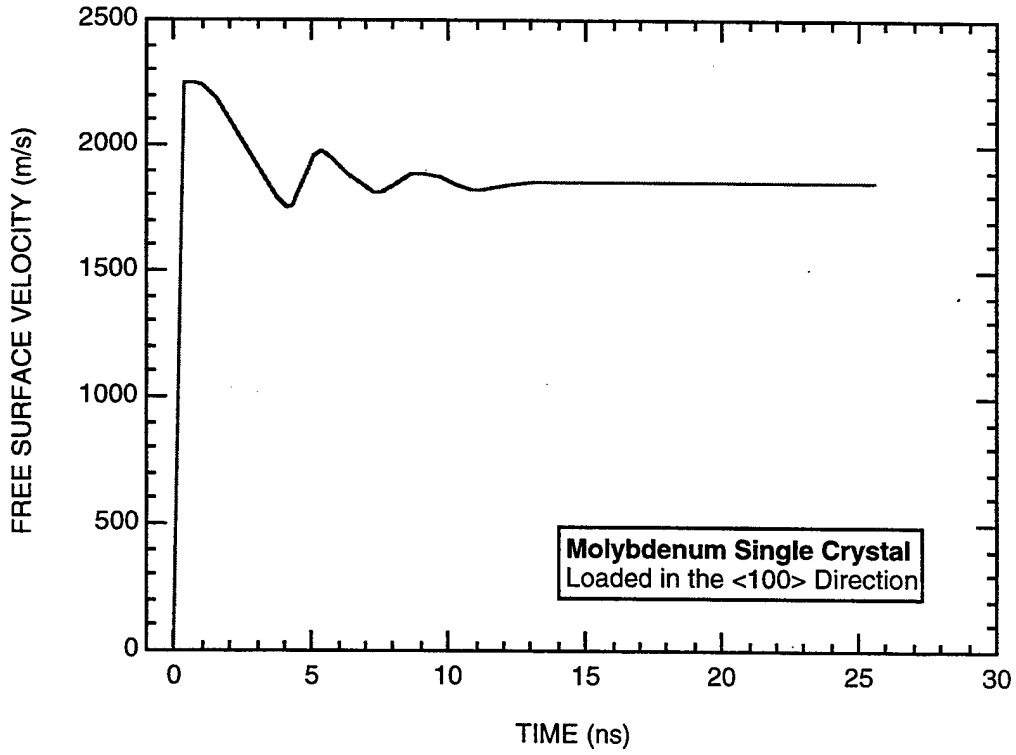


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Molybdenum[1] 0.1 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	13.4±0.2 GPa 0.01 mm (±10)

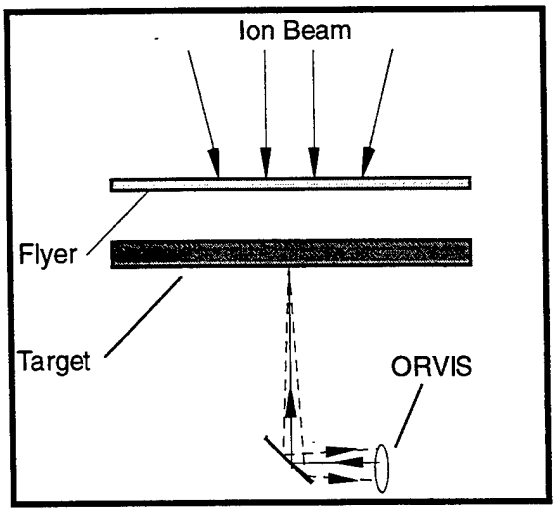
Reference: Kanel et al. (1993)

[1] Deformed (90% to 95%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <100>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

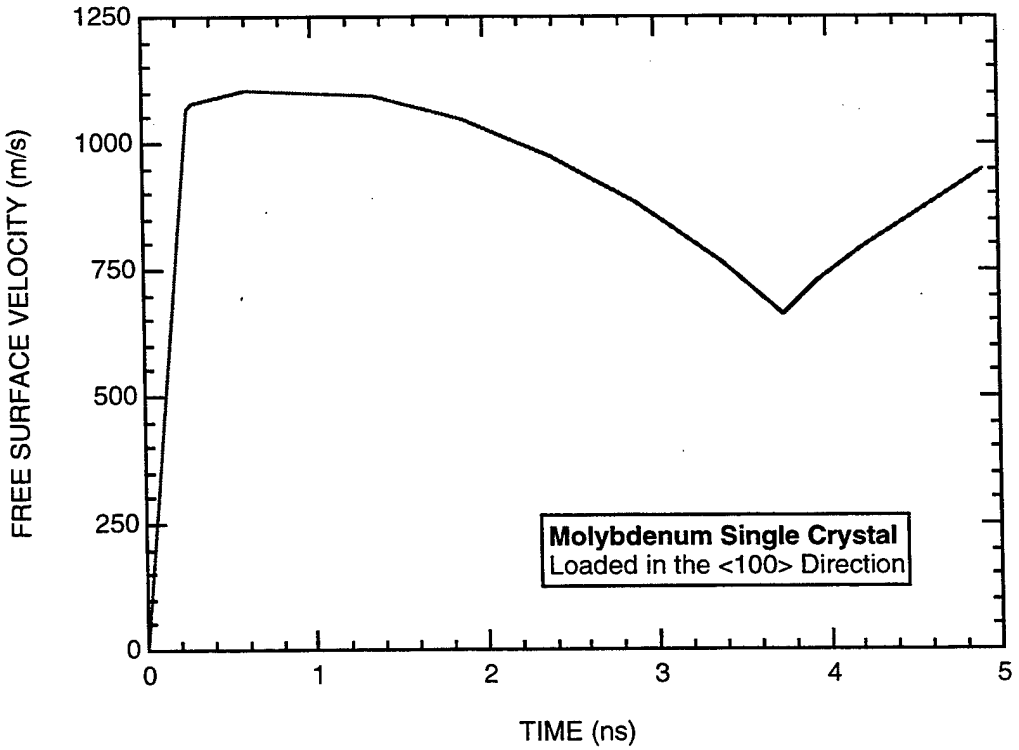


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	3500±150 m/s
Flyer plate: - material - thickness	Aluminum 0.01 mm
Target: - material - thickness	Molybdenum[1] 0.275 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	16.5±0.2 GPa 0.009 mm (±10)

Reference: Kanel et al. (1993)

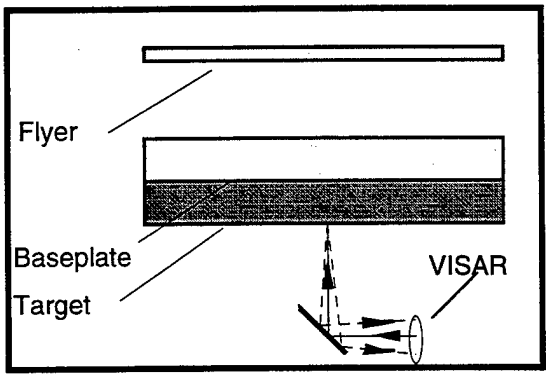
[1] Deformed (90% to 95%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



B.20 MOLYBDENUM SINGLE CRYSTAL, <110>.

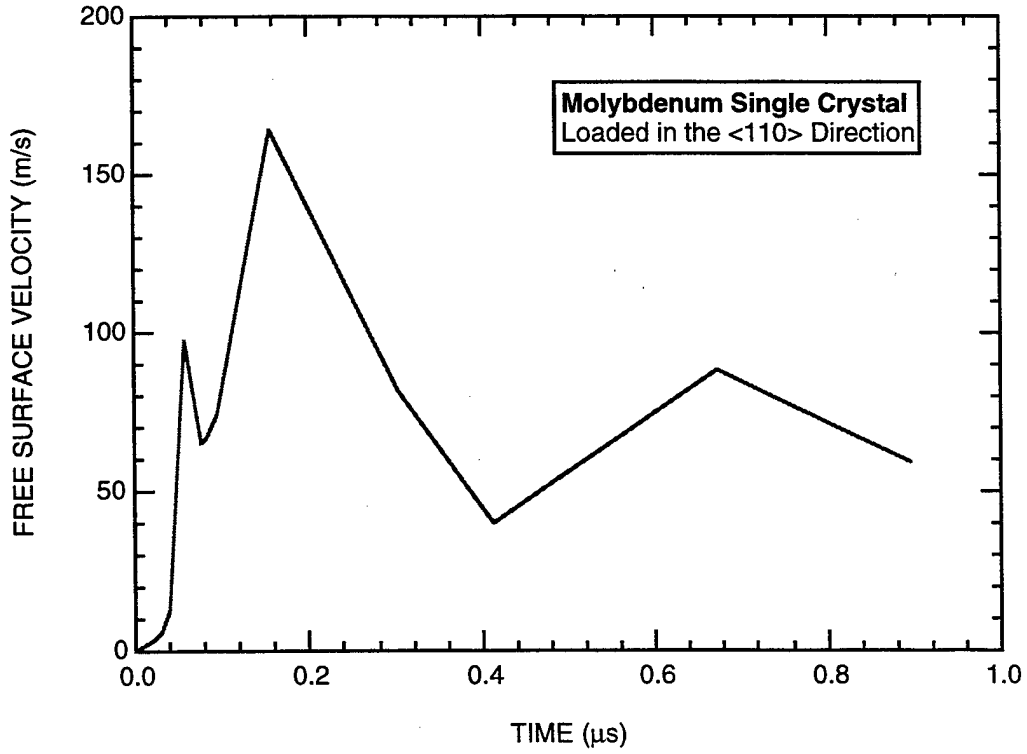
Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



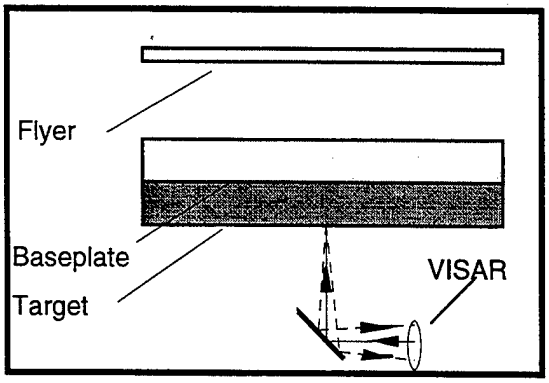
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum[1] 1.37 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.2±0.2 GPa 1.8 mm (±10%)

[1] Single crystal loaded in the <110> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



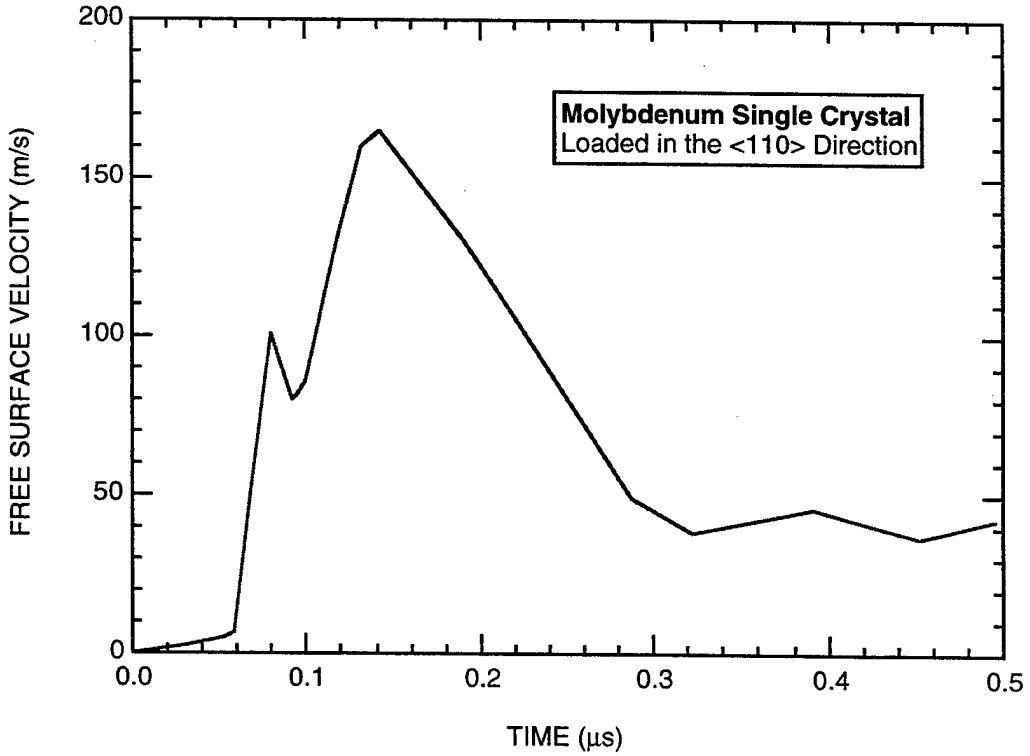
Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



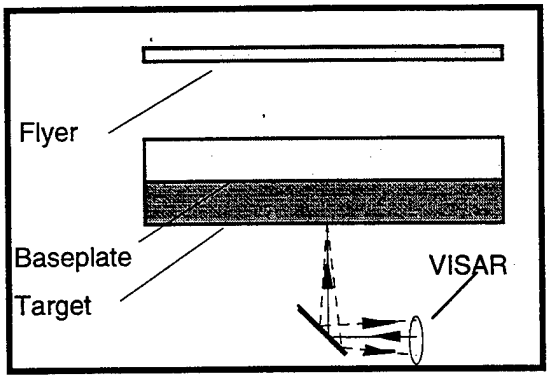
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 1.45 mm
Target: - material - thickness	Molybdenum[1] 1.45 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	No spall

Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <110> direction.



Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

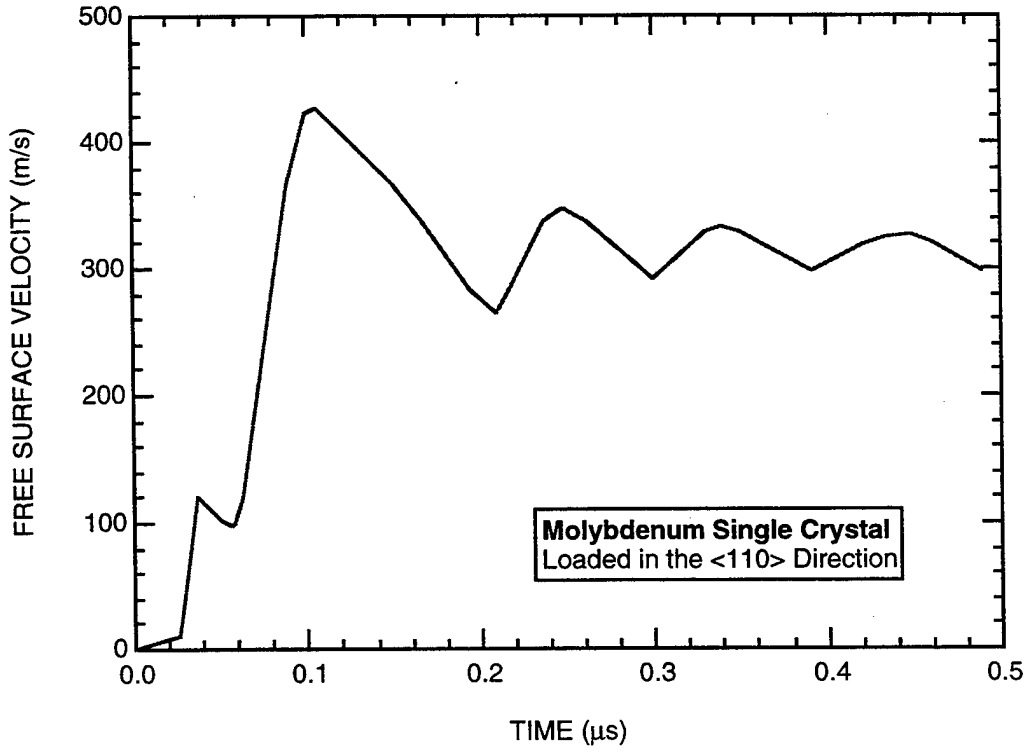


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1250±70 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 1.96 mm
Target: - material - thickness	Molybdenum[1] 1.47 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	4.6±0.1 GPa 0.29 mm (±10%)

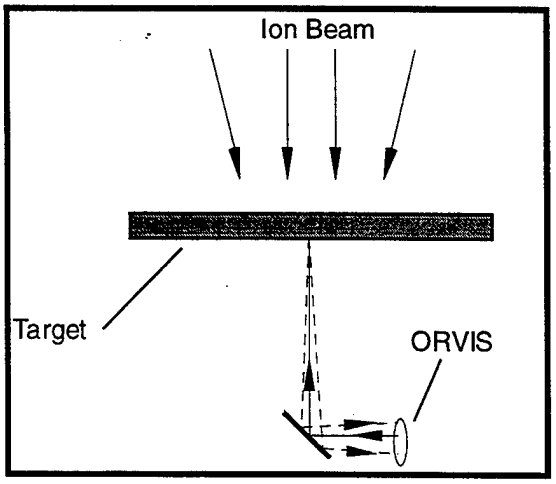
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <110> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

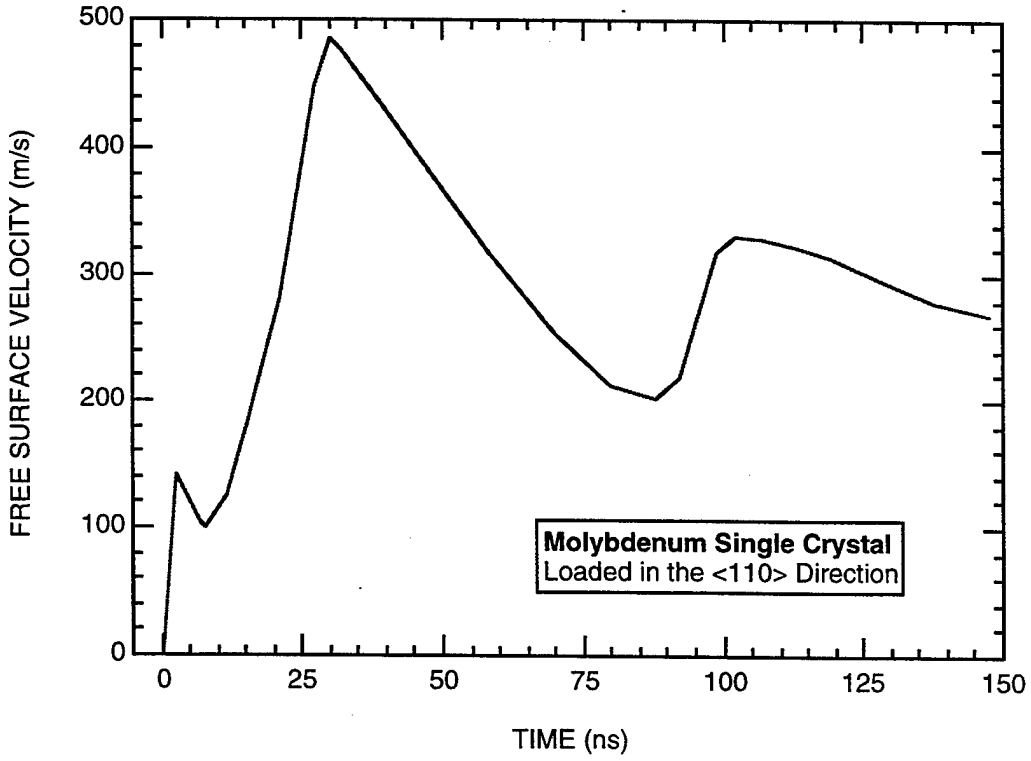


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Molybdenum[1] 0.9 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	8.0±0.1 GPa 0.19 mm (±10%)

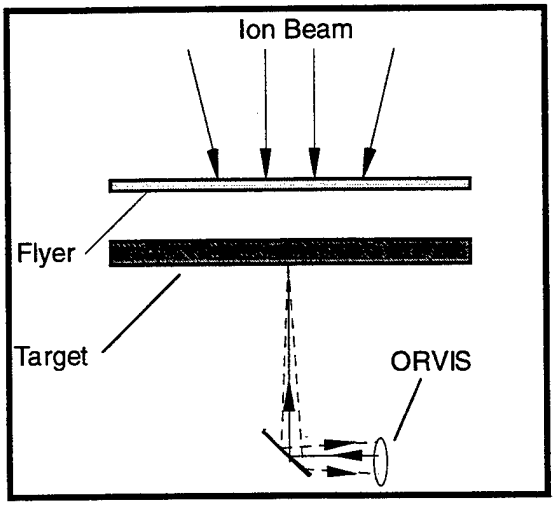
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <110> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

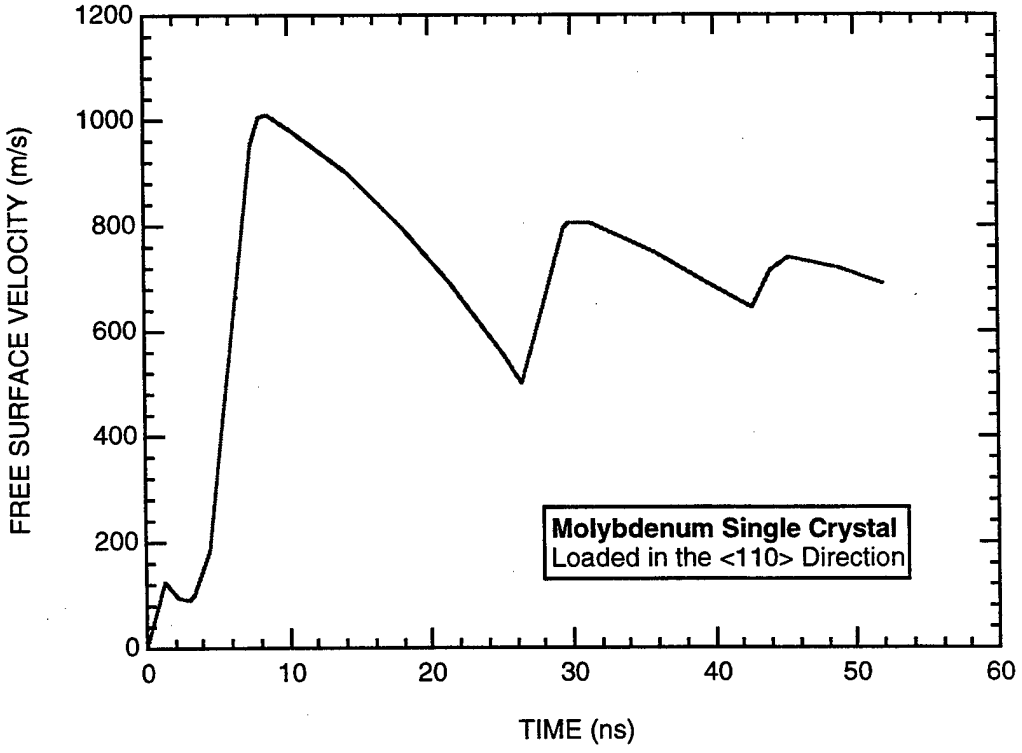


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Molybdenum[1] 0.416 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	13.93±0.1 GPa 0.048 mm (±10%)

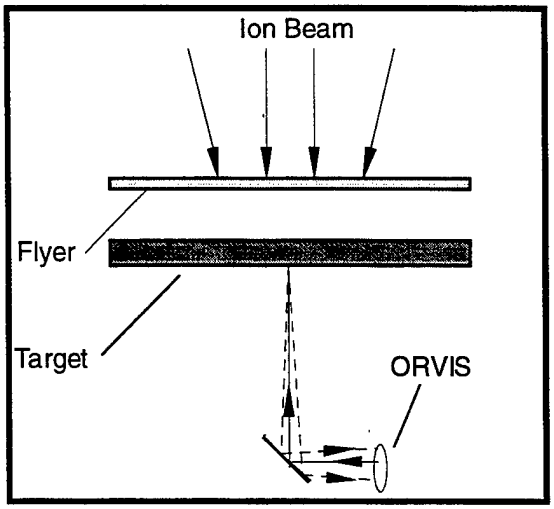
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <110> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

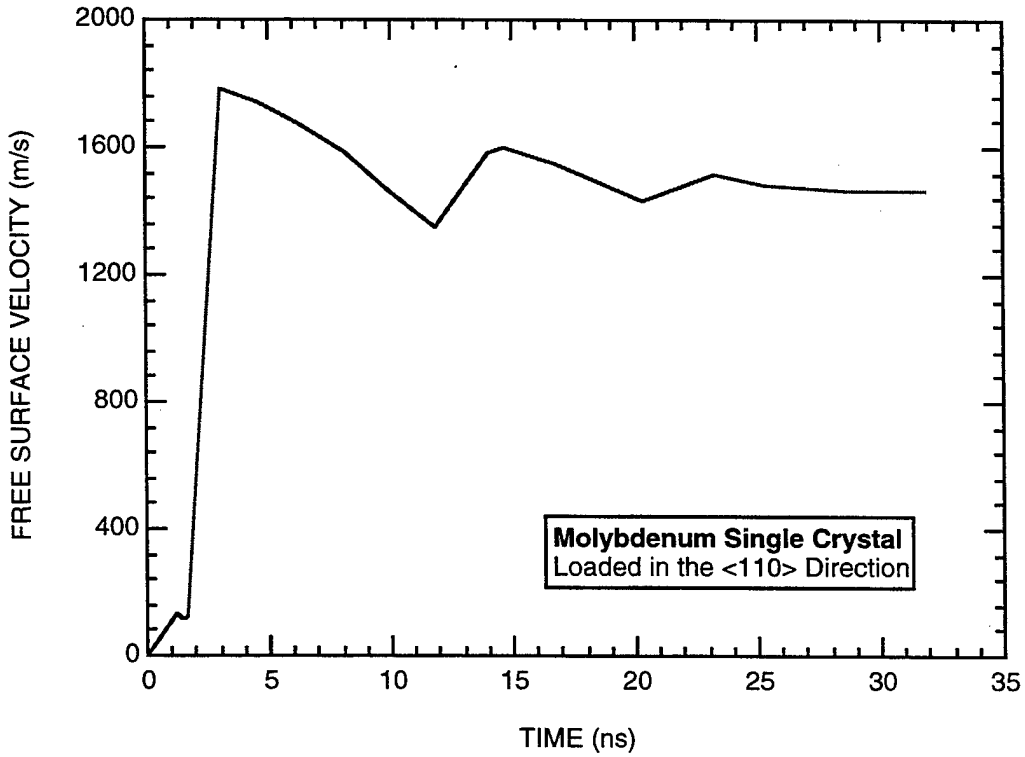


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Molybdenum[1] 0.286 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	11.82±0.1 GPa 0.027 mm (±10%)

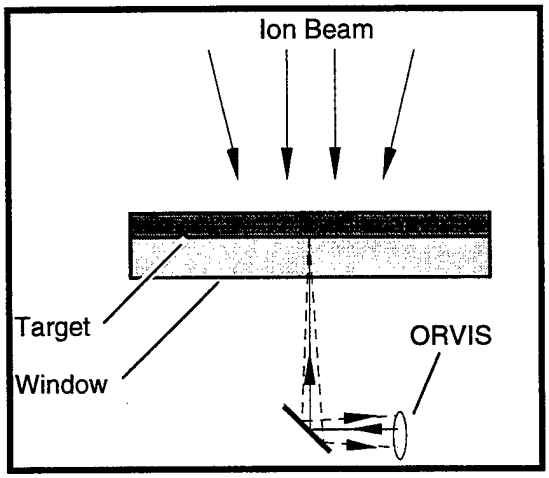
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <110> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



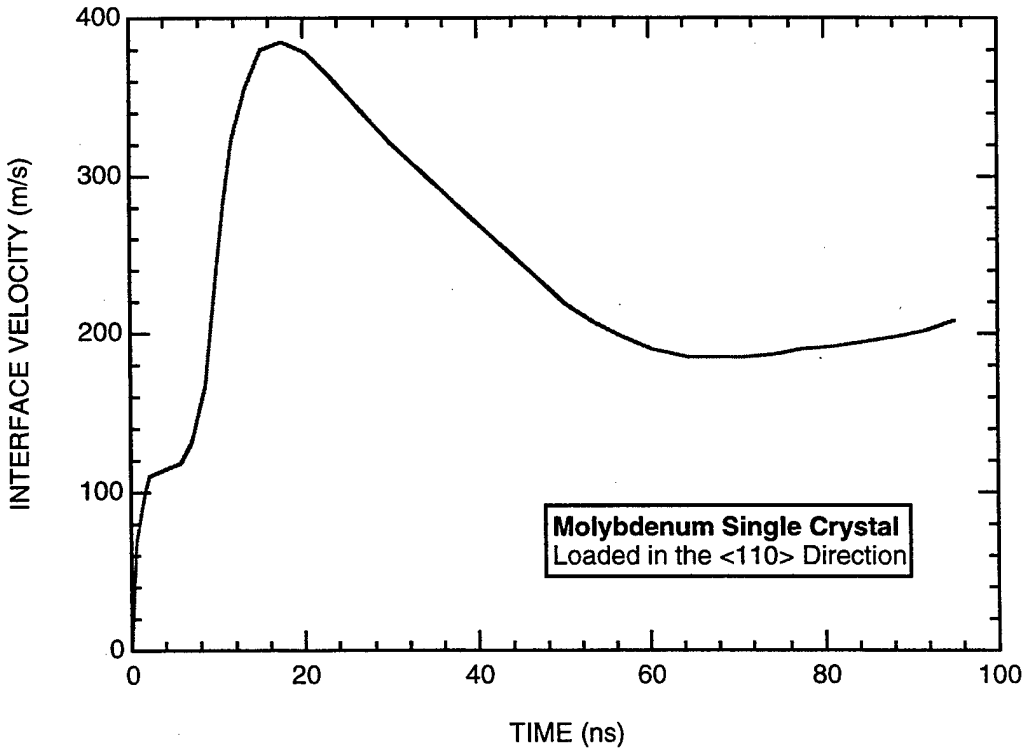
Molybdenum <110>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Molybdenum[1] 0.37 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength	Non observed

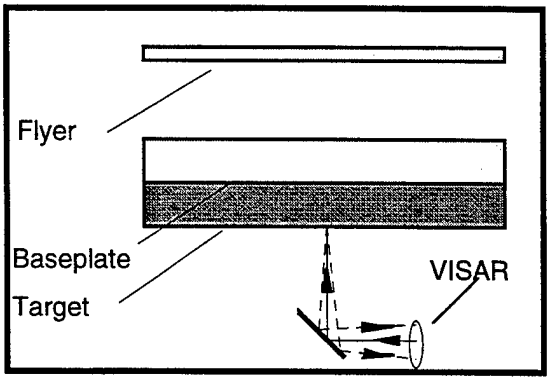
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <110> direction.



B.21 MOLYBDENUM SINGLE CRYSTAL, <111>.

Molybdenum <111>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

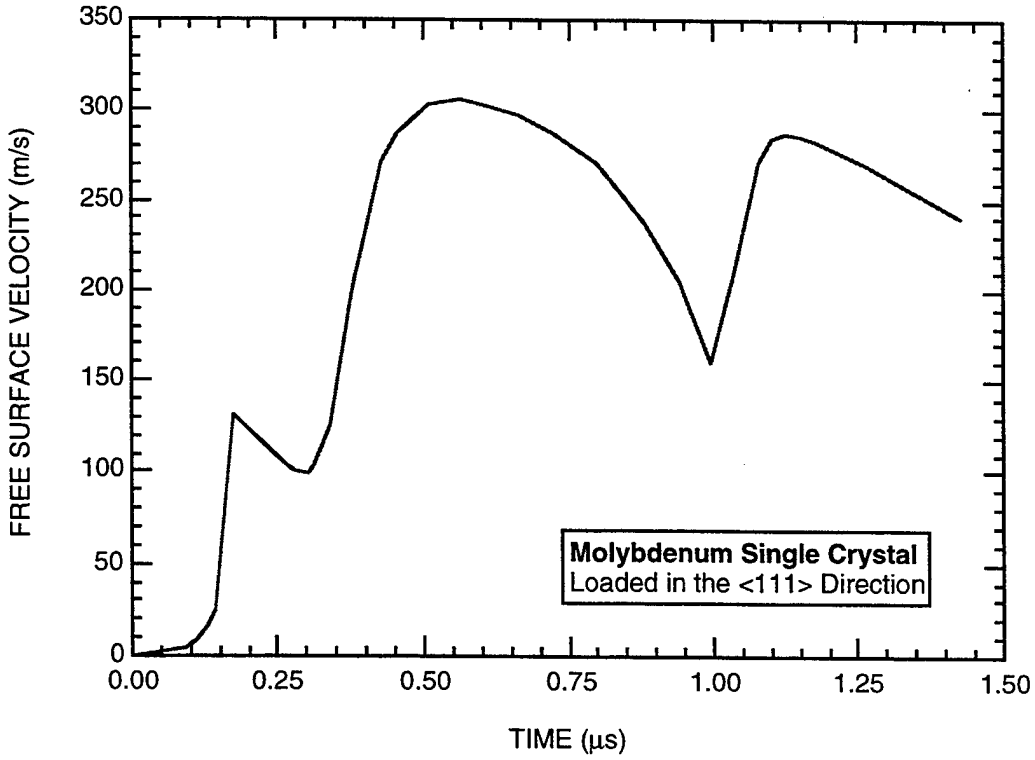


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4.7 mm
Target: - material - thickness	Molybdenum[1] 3.91 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	4.2±0.1 GPa 1.1 mm (±10%)

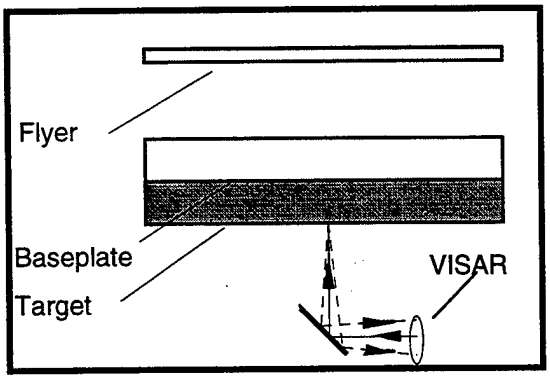
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <111> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <111>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

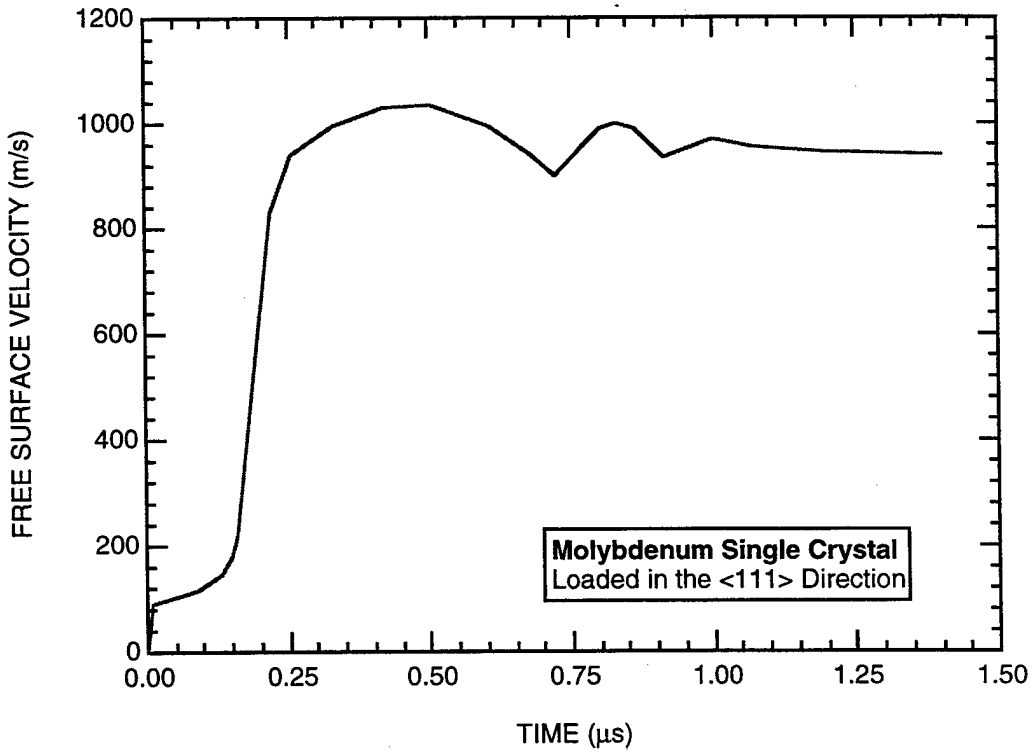


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4.7 mm
Target: - material - thickness	Molybdenum[1] 3.7 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.5±0.1 GPa 0.6 mm (±10%)

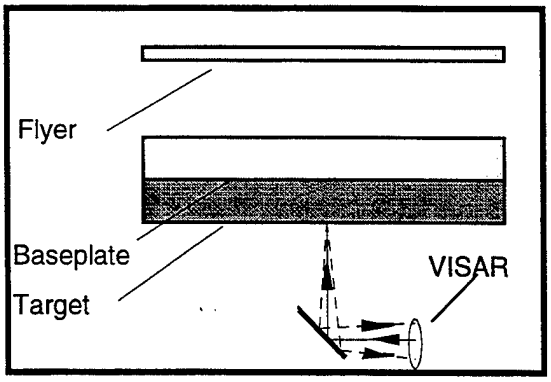
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <111> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <111>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

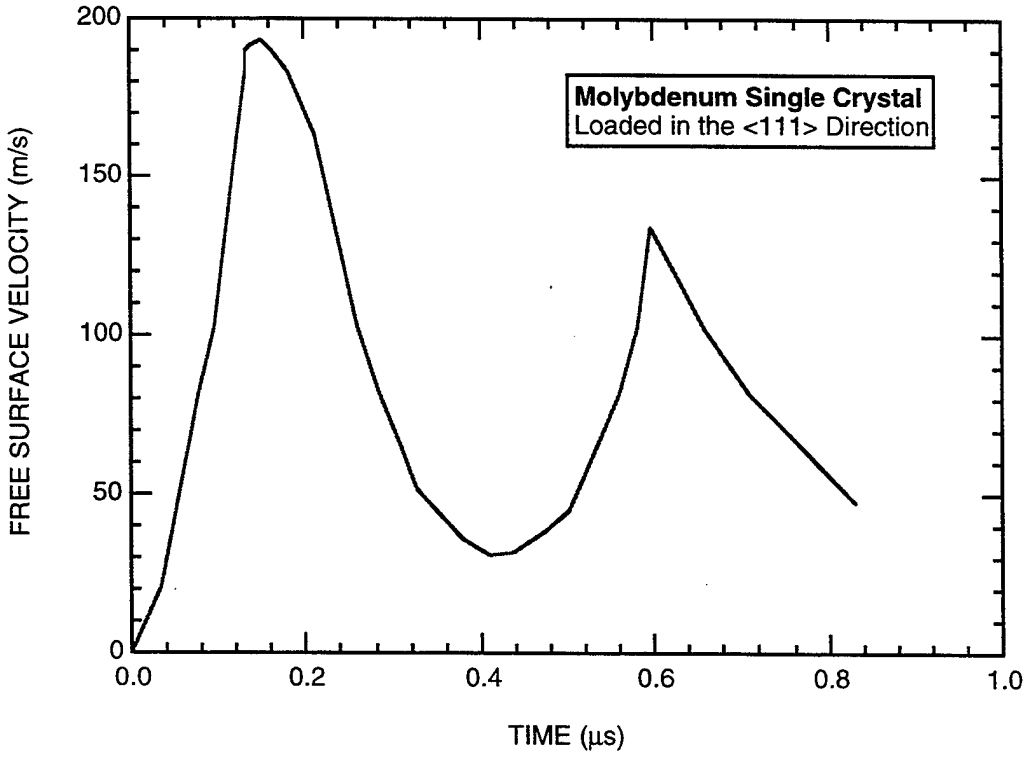


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum[1] 1.25 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	3.7±0.2 GPa 0.7 mm (±10%)

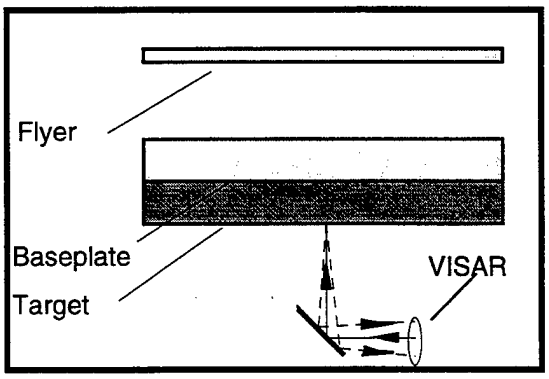
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <111> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Molybdenum <111>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs

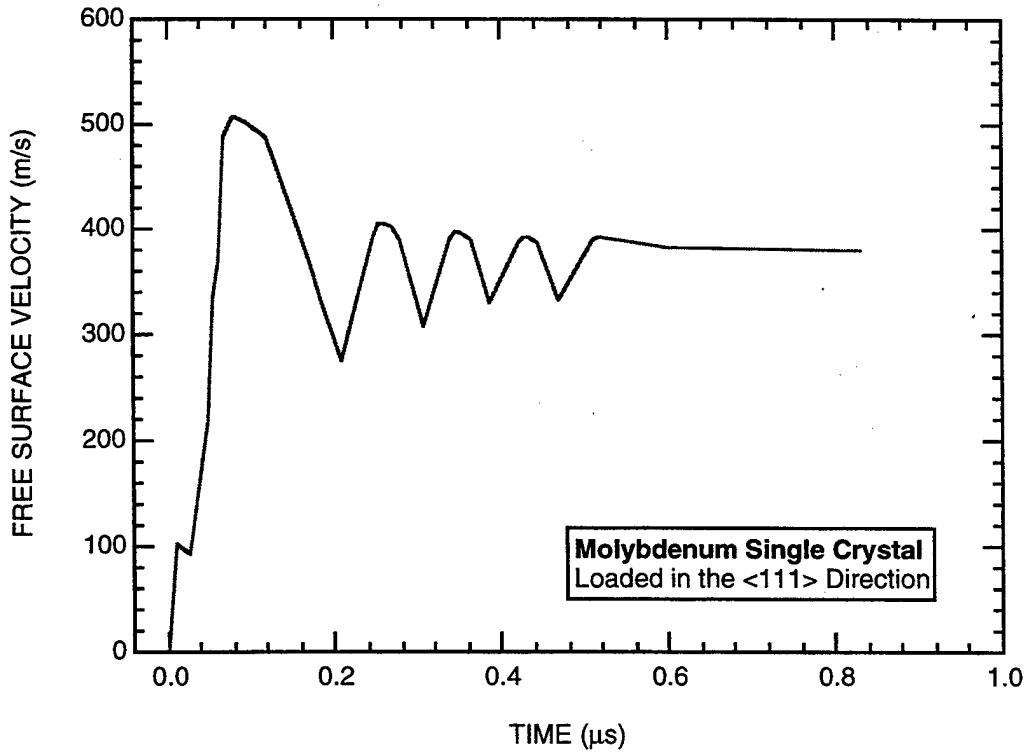


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1250±50 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Molybdenum[1] 1.34 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[2]	6.3±0.2 GPa 0.27 mm (±10%)

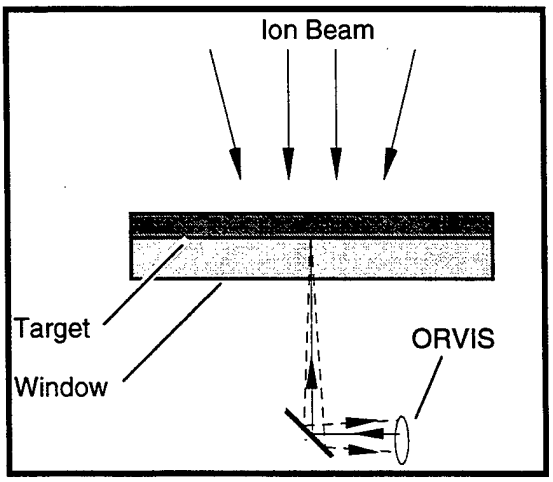
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <111> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



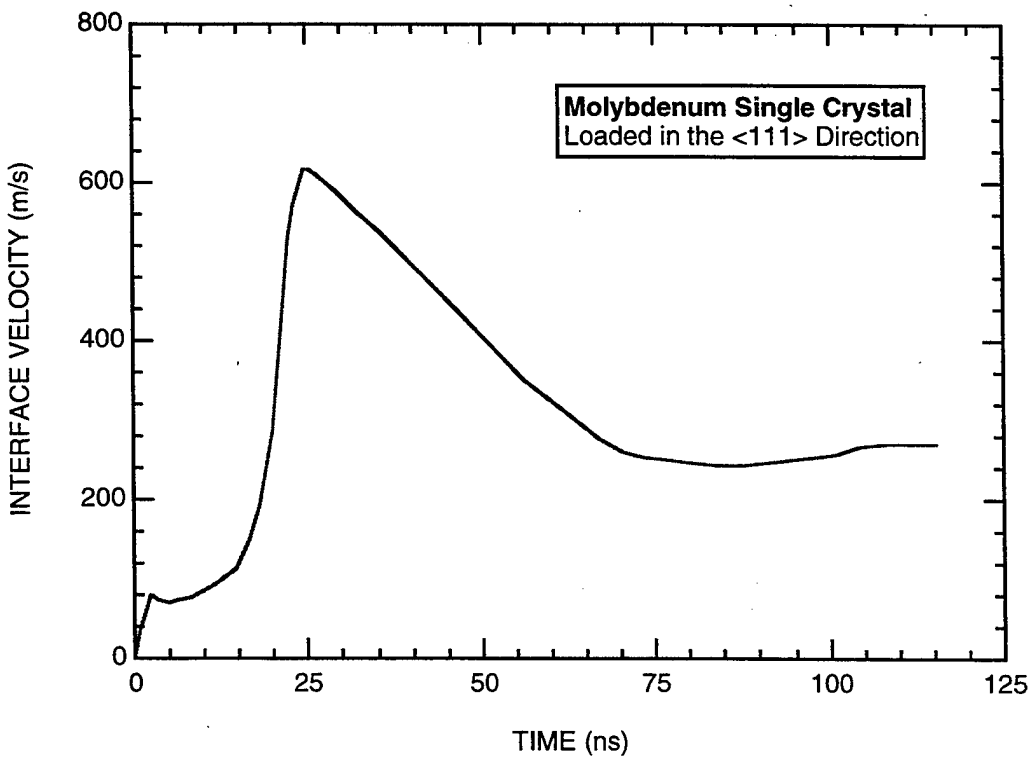
Molybdenum <111>	
Density	10.21 g/cm^3
Bulk sound velocity	5.14 mm/μs
Longitudinal sound velocity	6.44 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Molybdenum[1] 0.66 mm
Measurement technique	ORVIS (with water window)
Measurement accuracy	±20 m/s
Spall strength	Non observed

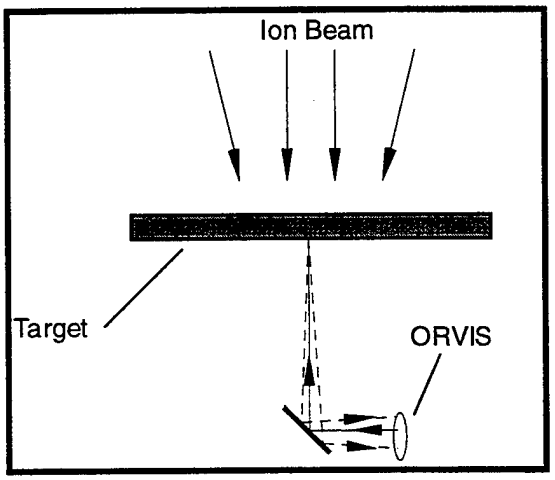
Reference: Kanel et al. (1993)

[1] Single crystal loaded in the <111> direction.



B.22 NIOBIUM SINGLE CRYSTAL, <100>.

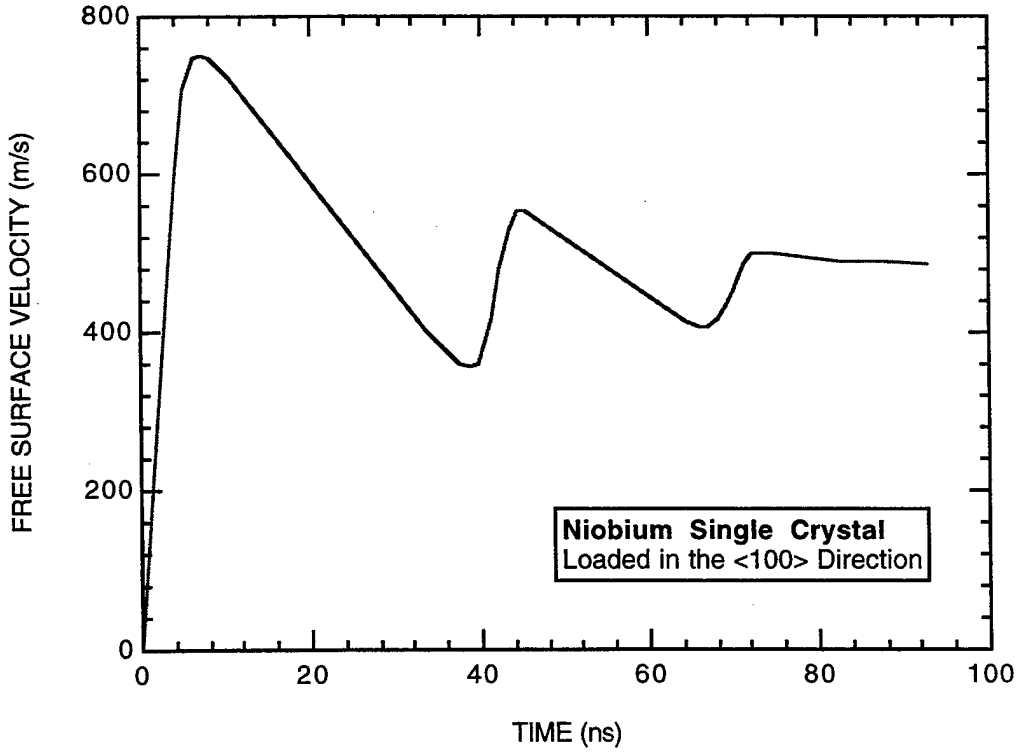
Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs



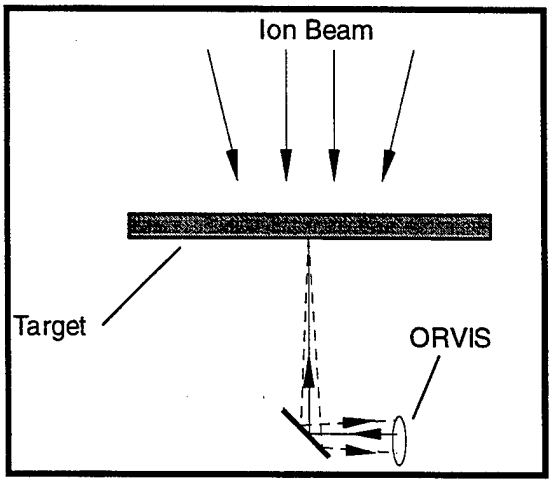
Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material - thickness	Niobium[1] 0.53 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	7.41±0.2 GPa 0.07 mm (±10%)

[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



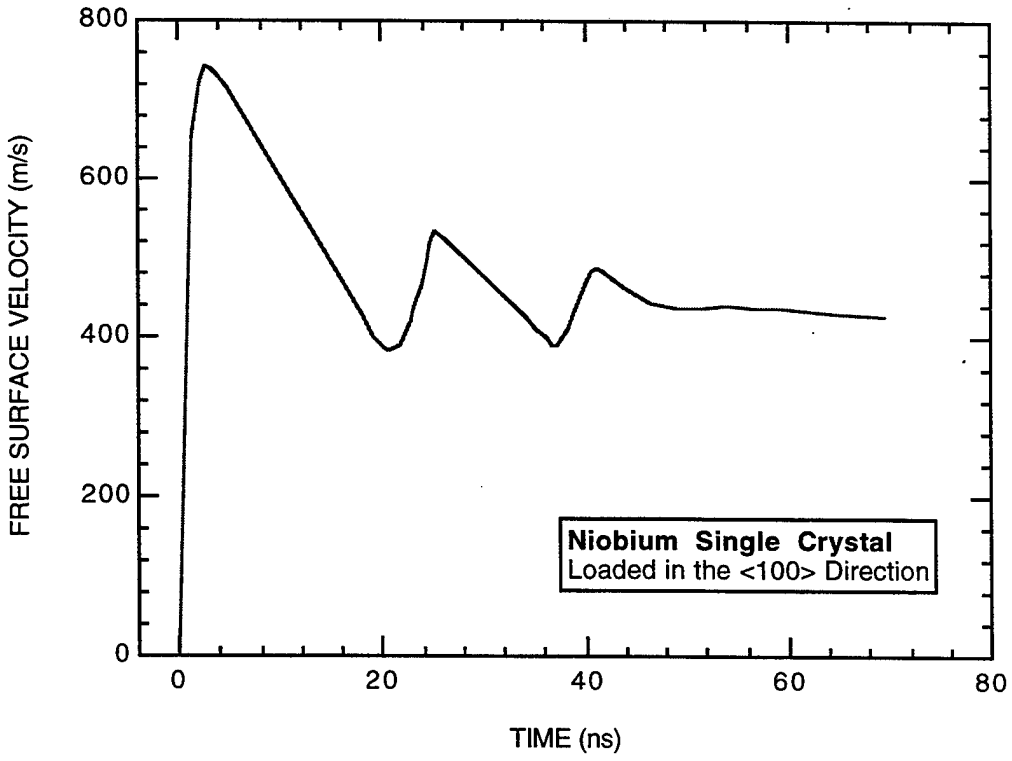
Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs



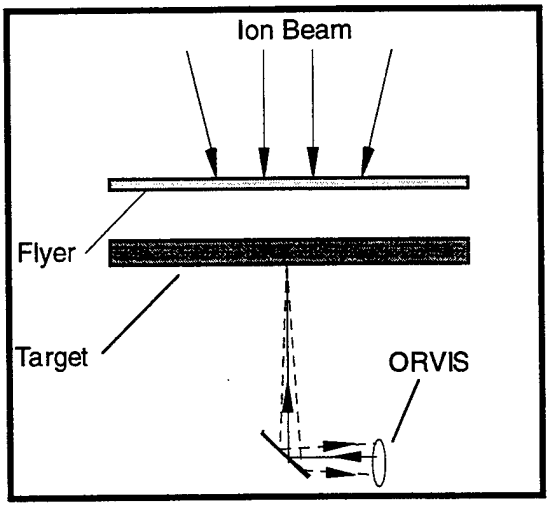
Experiment Summary	
Loading condition	1-D strain
Loading method	Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material	Niobium[1]
- thickness	0.455 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength	6.86±0.2 GPa
Spall thickness[2]	0.042 mm (±10%)

[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



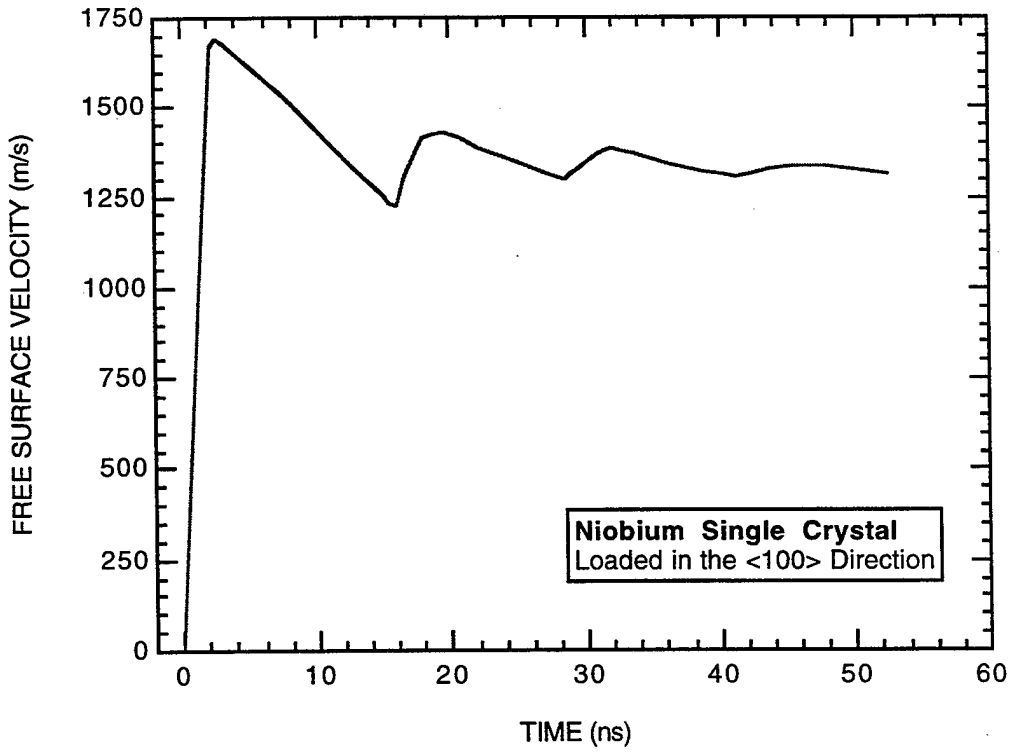
Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Niobium[1] 0.49 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	8.66±0.2 GPa 0.029 mm (±10%)

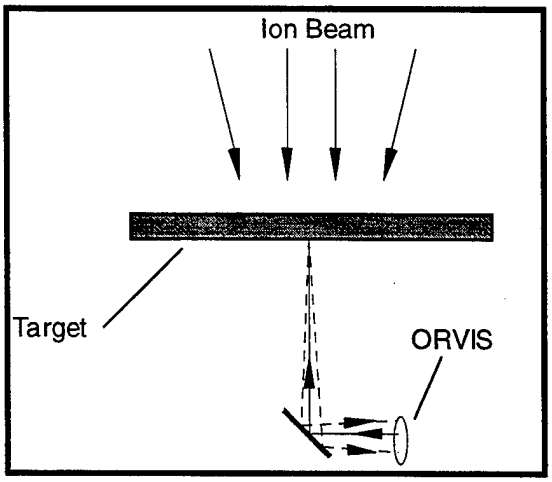
[1] Single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



B.23 NIOBIUM SINGLE CRYSTAL, <100>, DEFORMED.

Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs

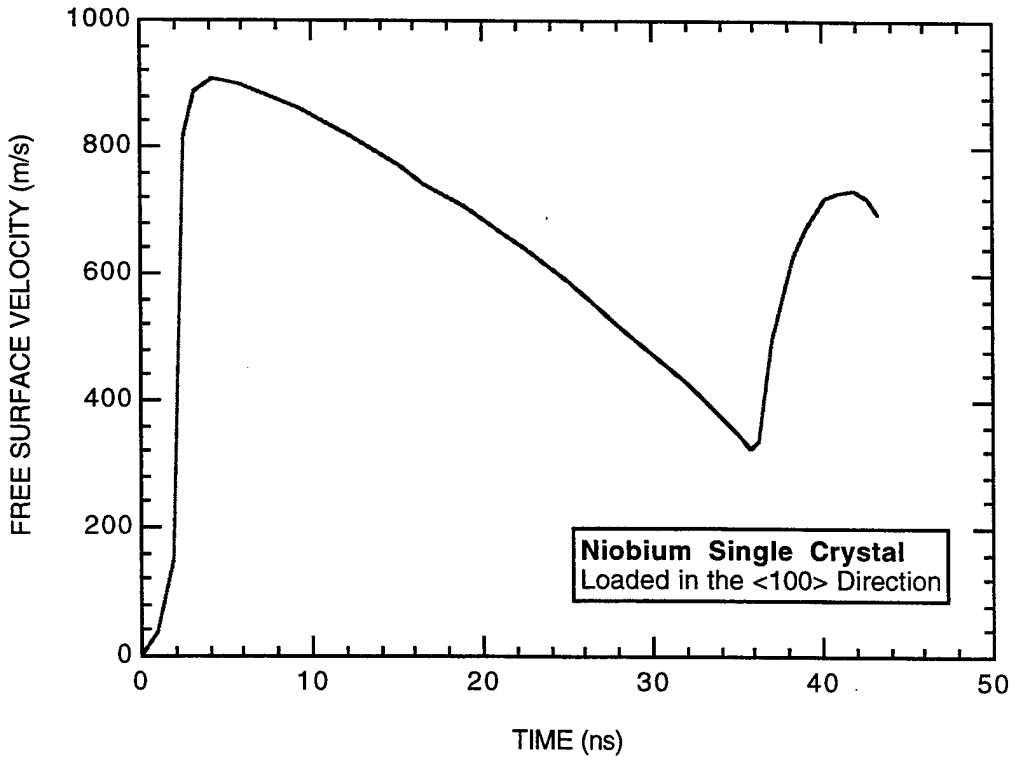


Experiment Summary	
Loading condition	1-D strain
Loading method	Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material	Niobium[1]
- thickness	0.4 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength	11.0±0.2 GPa
Spall thickness[2]	0.07 mm (±10%)

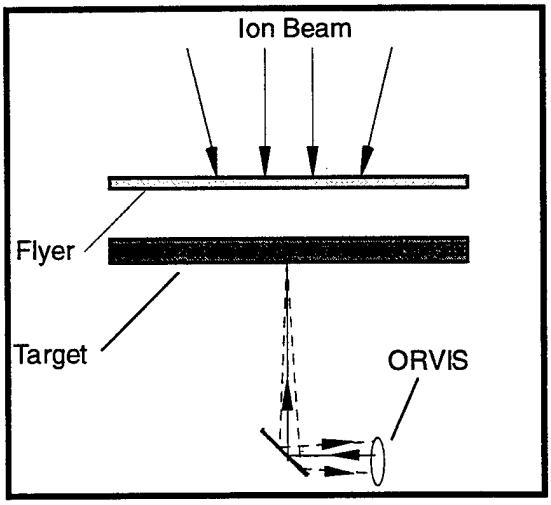
Reference: Kanel et al. (1994)

[1] Deformed (85% to 90%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs

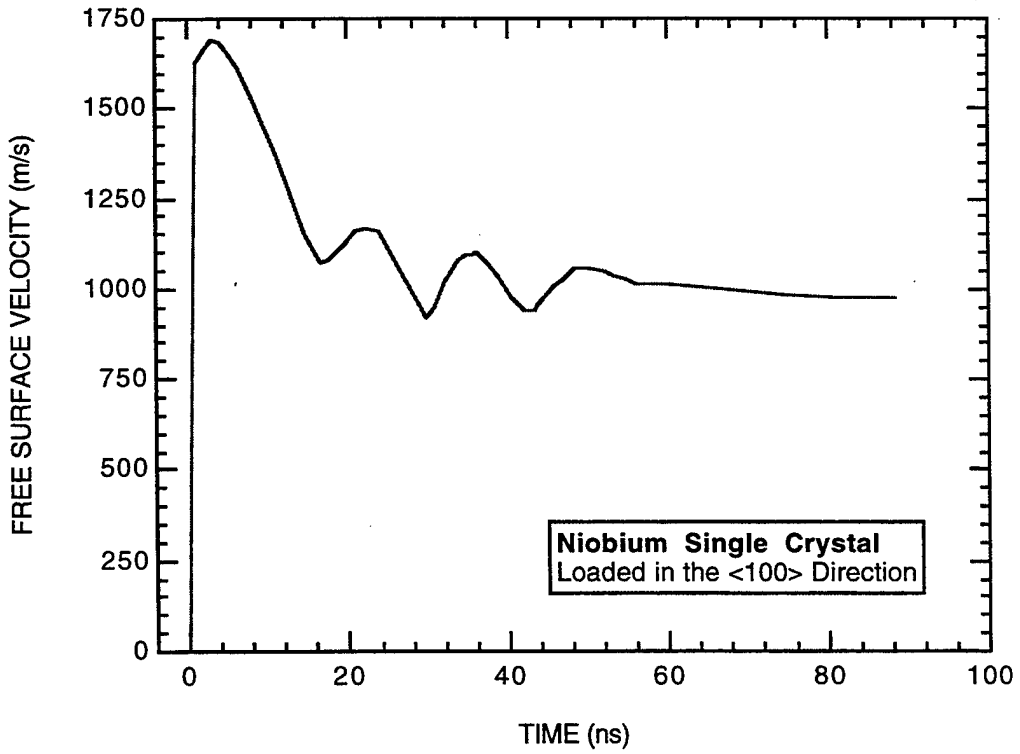


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Niobium[1] 0.44 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	11.15±0.2 GPa 0.029 mm (±10%)

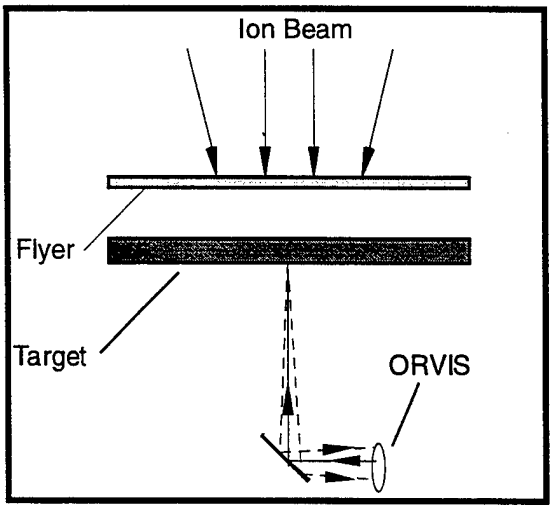
Reference: Kanel et al. (1994)

[1] Deformed (85% to 90%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs

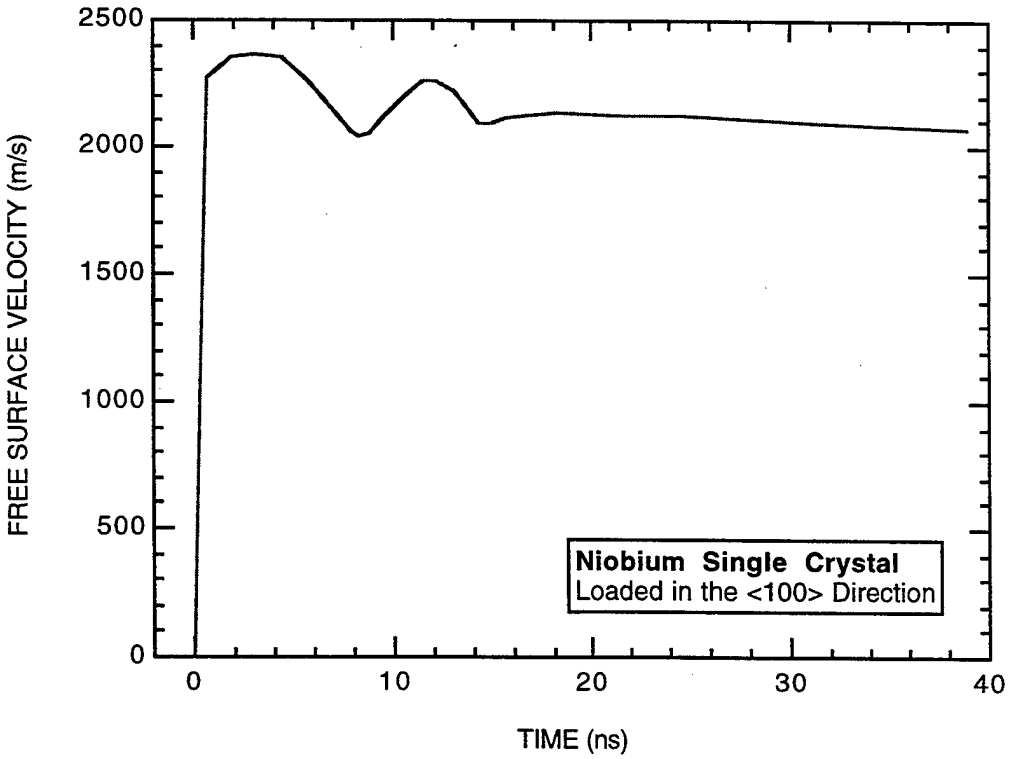


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Niobium[1] 0.09 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	6.45±0.2 GPa 0.014 mm (±10%)

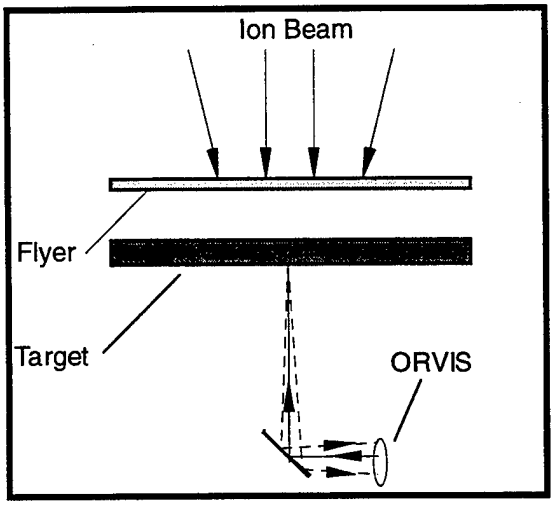
Reference: Kanel et al. (1994)

[1] Deformed (85% to 90%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs

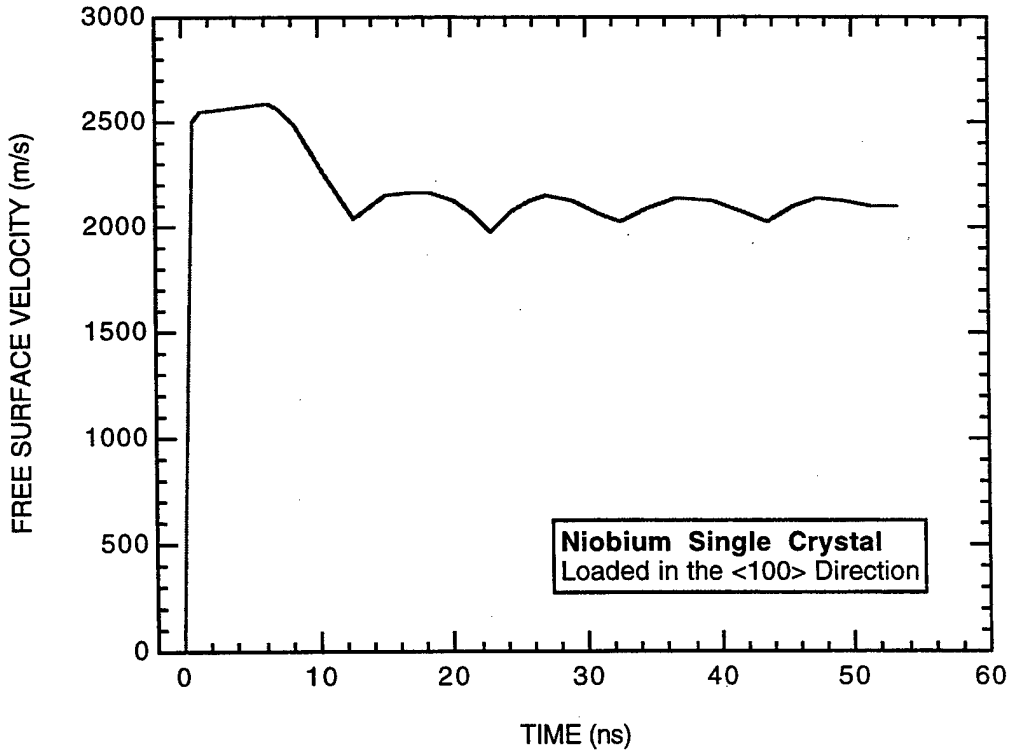


Experiment Summary	
Loading condition Loading method	1-D strain Ion beam-launched flyer plate
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Impact velocity	4100±150 m/s
Flyer plate: - material - thickness	Aluminum 0.05 mm
Target: - material - thickness	Niobium[1] 0.068 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength Spall thickness[2]	10.1±0.2 GPa 0.023 mm (±10%)

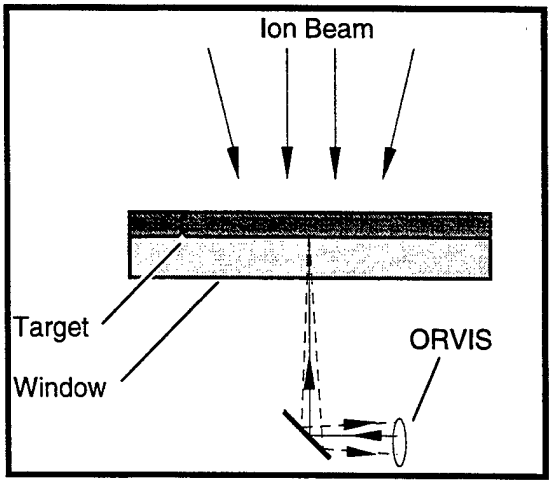
Reference: Kanel et al. (1994)

[1] Deformed (85% to 90%) single crystal loaded in the <100> direction.

[2] Determined based on the period of oscillation in the measured velocity history.



Niobium <100>	
Density	8.59 g/cm^3
Bulk sound velocity	4.44 mm/μs
Longitudinal sound velocity	5.03 mm/μs



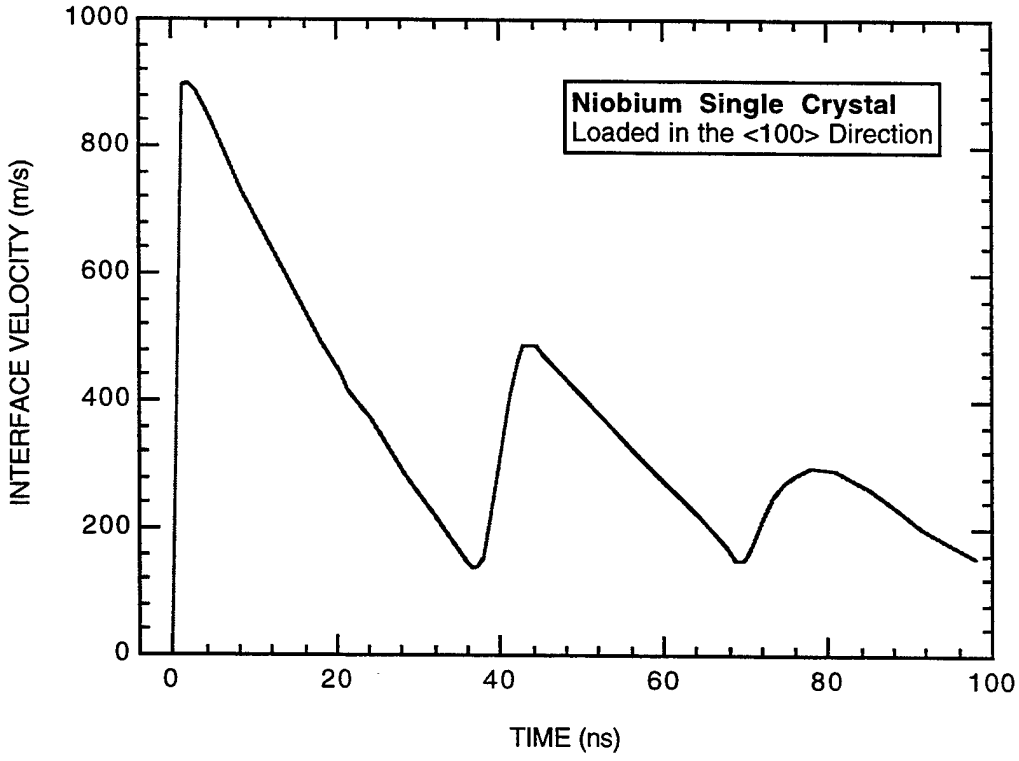
Experiment Summary	
Loading condition	1-D strain
Loading method	Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	8 mm
Target: - material	Niobium[1]
- thickness	0.41 mm
Measurement technique[2]	ORVIS
Measurement accuracy	±20 m/s
Spall strength	10.1±0.2 GPa
Spall thickness[3]	0.07 mm (±10%)

Reference: Kanel et al. (1994)

[1] Deformed (85% to 90%) single crystal loaded in the <100> direction.

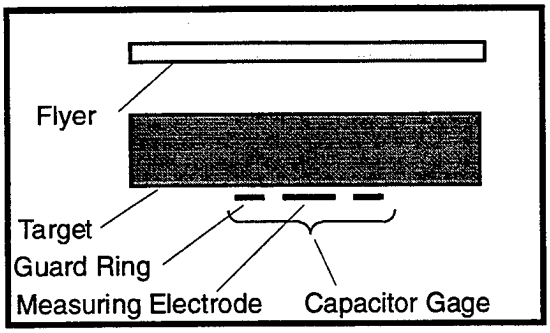
[2] Measurement performed through water window.

[3] Determined based on the period of oscillation in the measured velocity history.



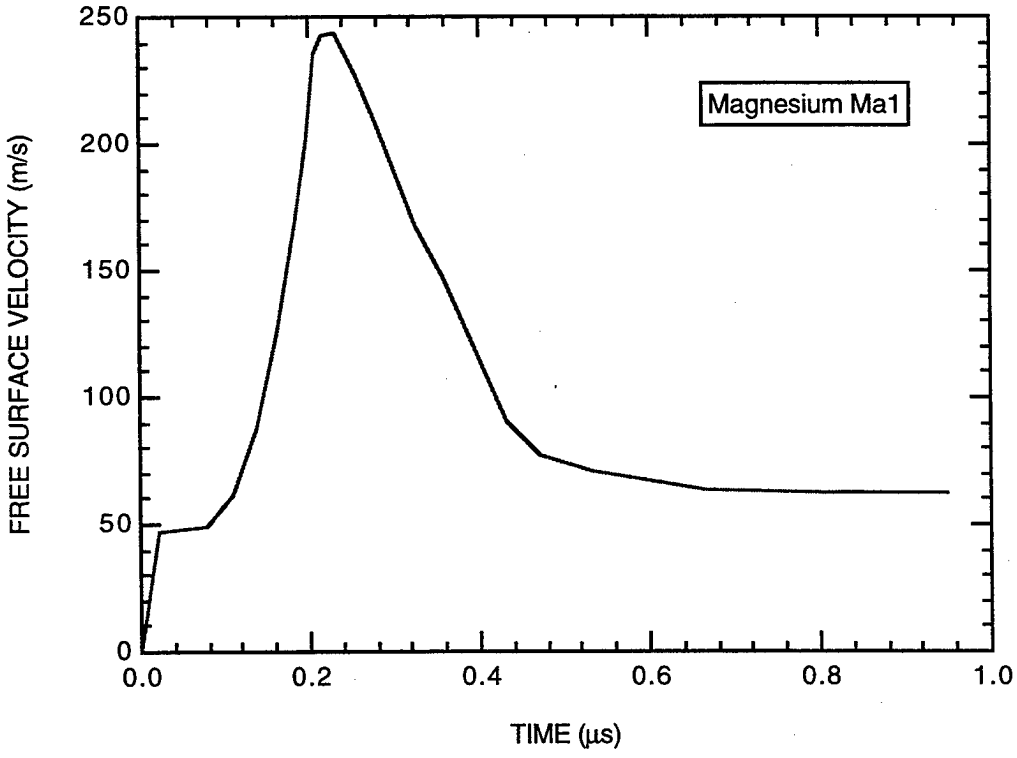
B.24 MAGNESIUM.

Magnesium Ma1	
Density	1.75 g/cm^3
Bulk sound velocity	4.5 mm/μs
Longitudinal sound velocity	5.61 mm/μs

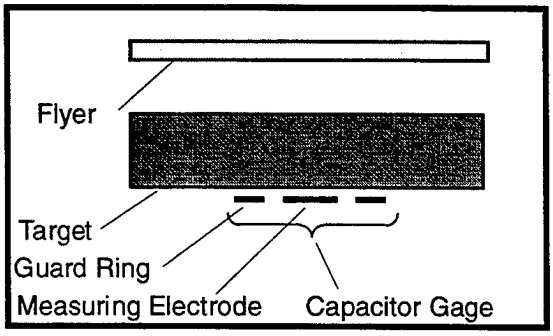


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Magnesium 1 (sheet) 4.9 mm
Measurement technique Electrode diameter	Capacitor gage 10 mm
Measurement accuracy	±4%
Spall strength	No spall

Reference: Kanel et al. (1984b)



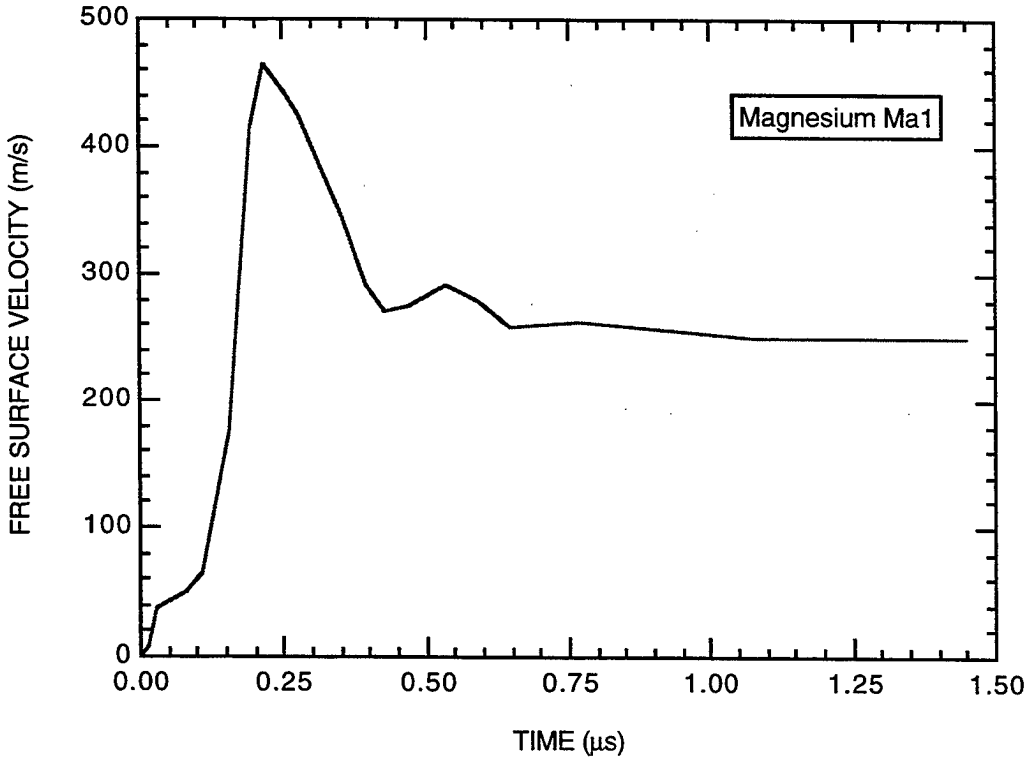
Magnesium Ma1	
Density	1.75 g/cm^3
Bulk sound velocity	4.5 mm/μs
Longitudinal sound velocity	5.61 mm/μs



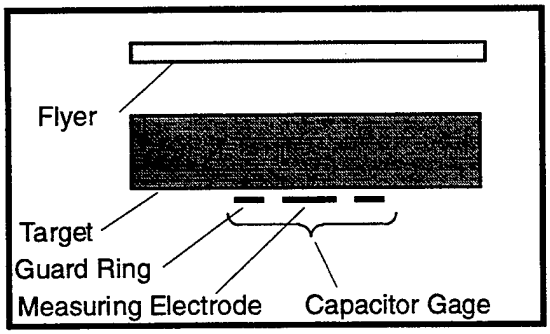
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Target: - material - thickness	Magnesium 1 (sheet) 4.9 mm
Measurement technique Electrode diameter	Capacitor gage 10 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.8±0.05 GPa 0.62 mm (±10%)

Reference: Kanel et al. (1984b)

[1] Determined based on the period of oscillation in the measured free surface velocity history.



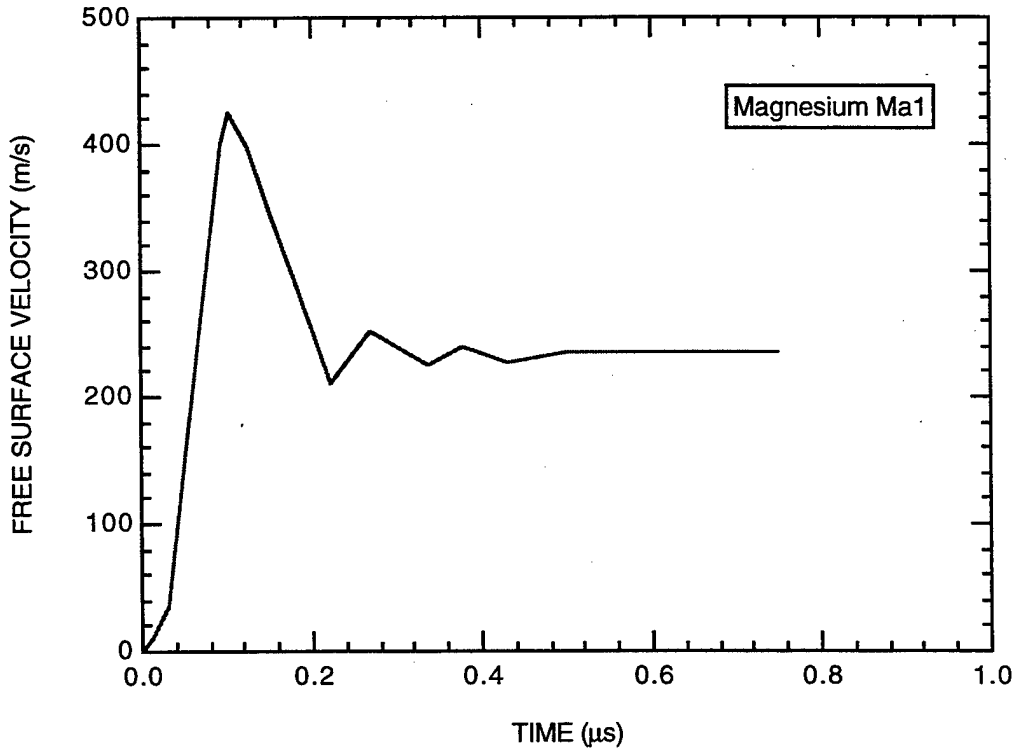
Magnesium Ma1	
Density	1.75 g/cm^3
Bulk sound velocity	4.5 mm/μs
Longitudinal sound velocity	5.61 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Target: - material - thickness	Magnesium 1 (sheet) 2.0 mm
Measurement technique Electrode diameter	Capacitor gage 5 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	0.88±0.05 GPa 0.3 mm (±10%)

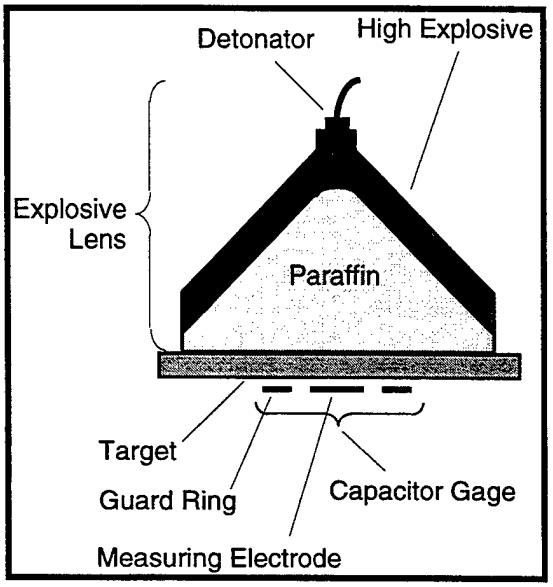
Reference: Kanel et al. (1984b)

[1] Determined based on the period of oscillation in the measured free surface velocity history.



B.25 ARMCO IRON.

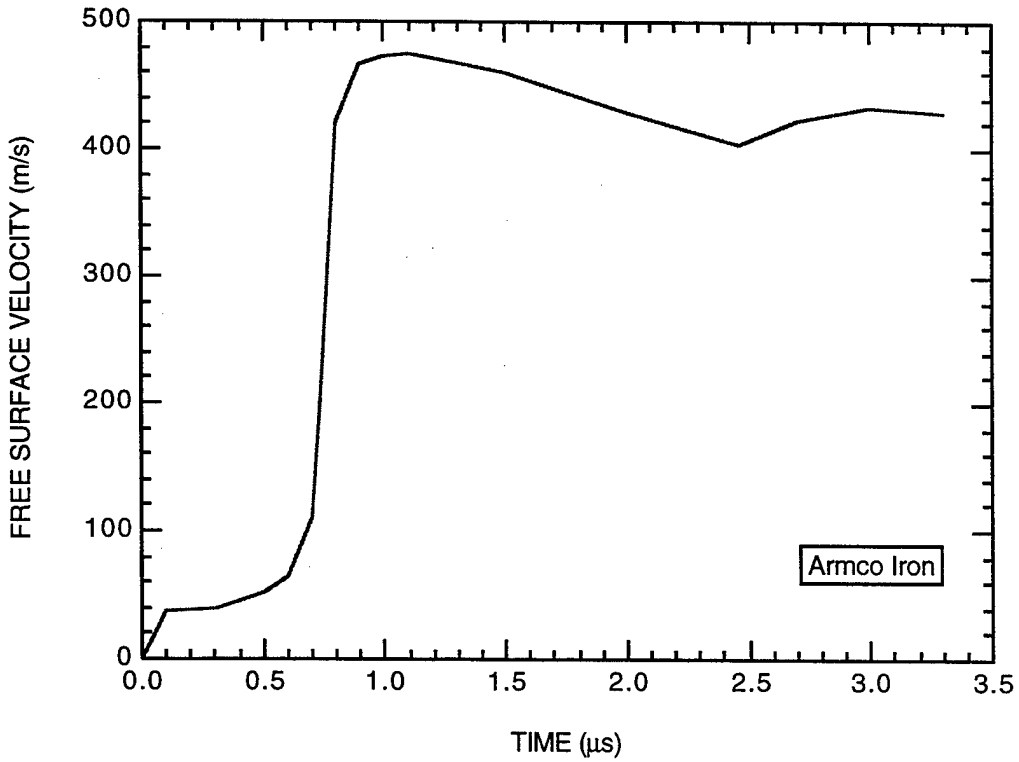
Armco Iron	
Density	7.80 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



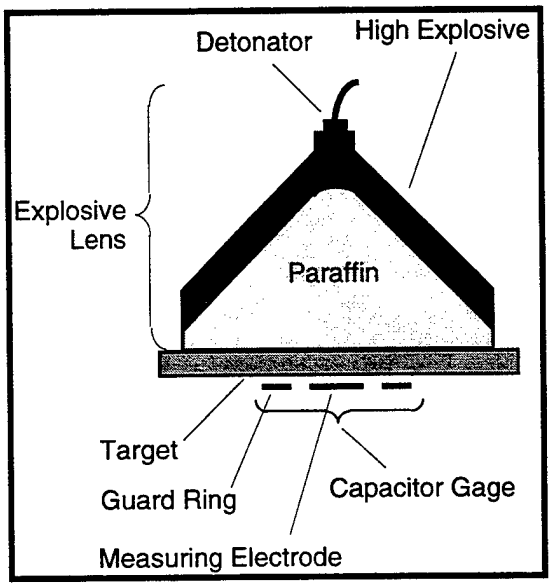
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	Armco iron (rod) 20 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.31±0.09 GPa 4.2 mm (±10%)

Reference: Kanel and Shcherban (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



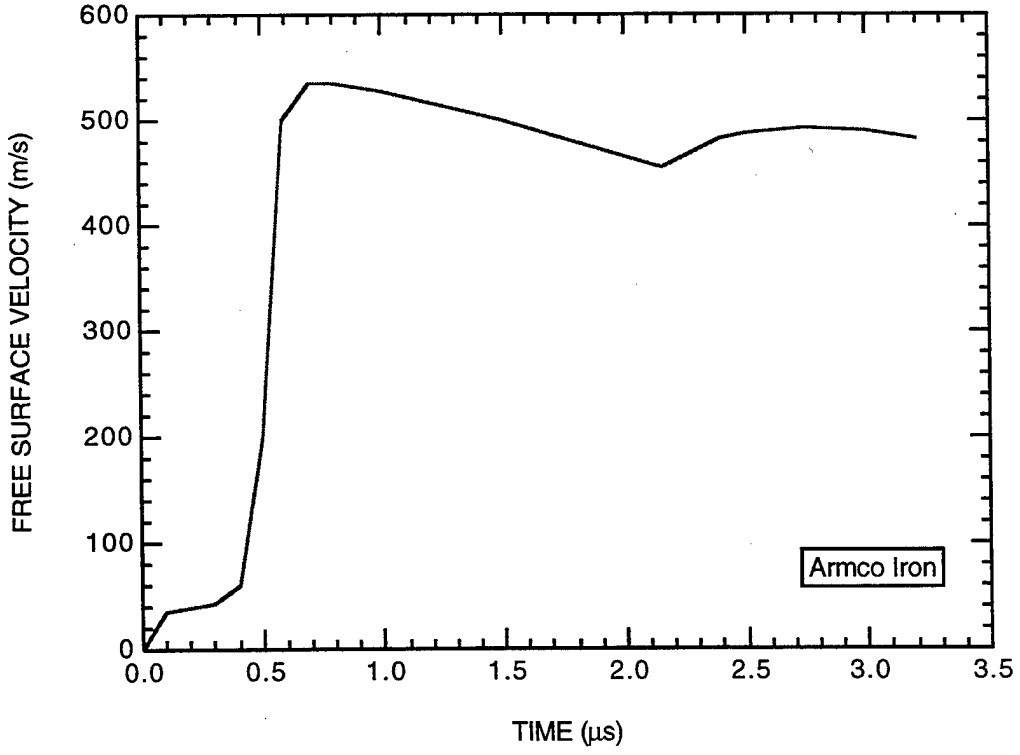
Armco Iron	
Density	7.80 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



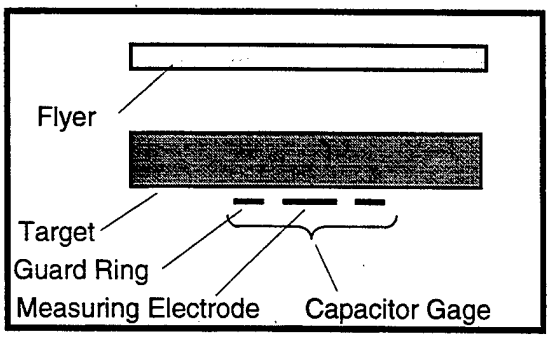
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	Armco iron (rod) 12 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.41±0.09 GPa 3.9 mm (±10%)

Reference: Kanel and Shcherban (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



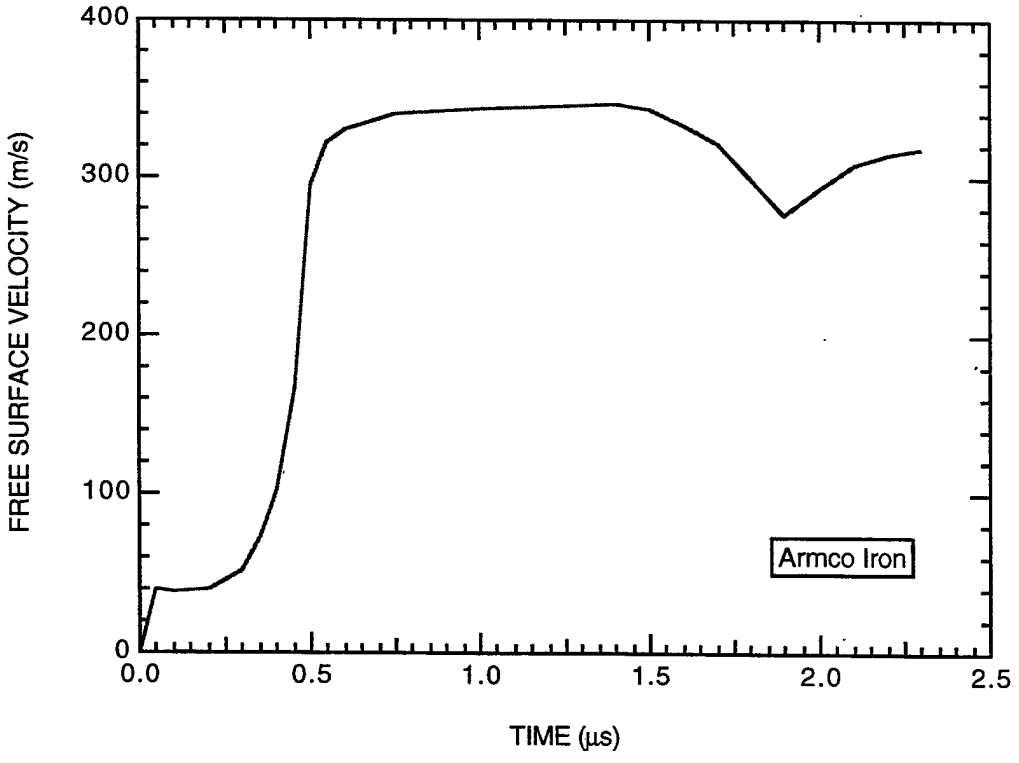
Armco Iron	
Density	7.80 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



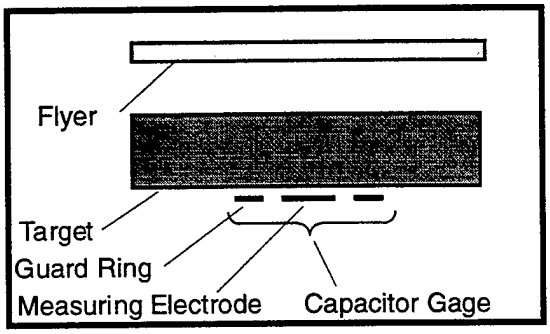
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	590±20 m/s
Flyer plate: - material - thickness	Aluminum 5 mm
Target: - material - thickness	Armco iron (rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.31±0.07 GPa 3.5 mm (±10%)

Reference: Kanel and Shcherban (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



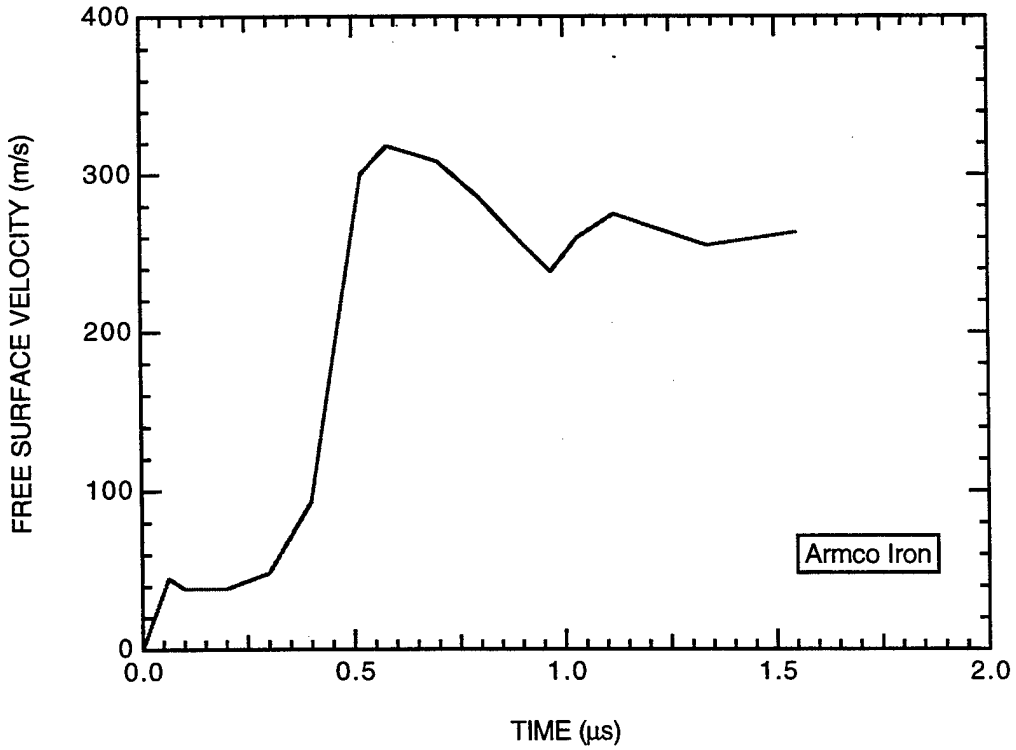
Armco Iron	
Density	7.80 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



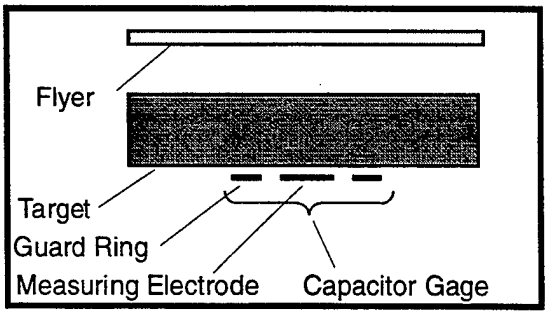
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	590±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Armco iron (rod) 10 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.54±0.09 GPa 1.1 mm (±10%)

Reference: Kanel and Shcherban (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



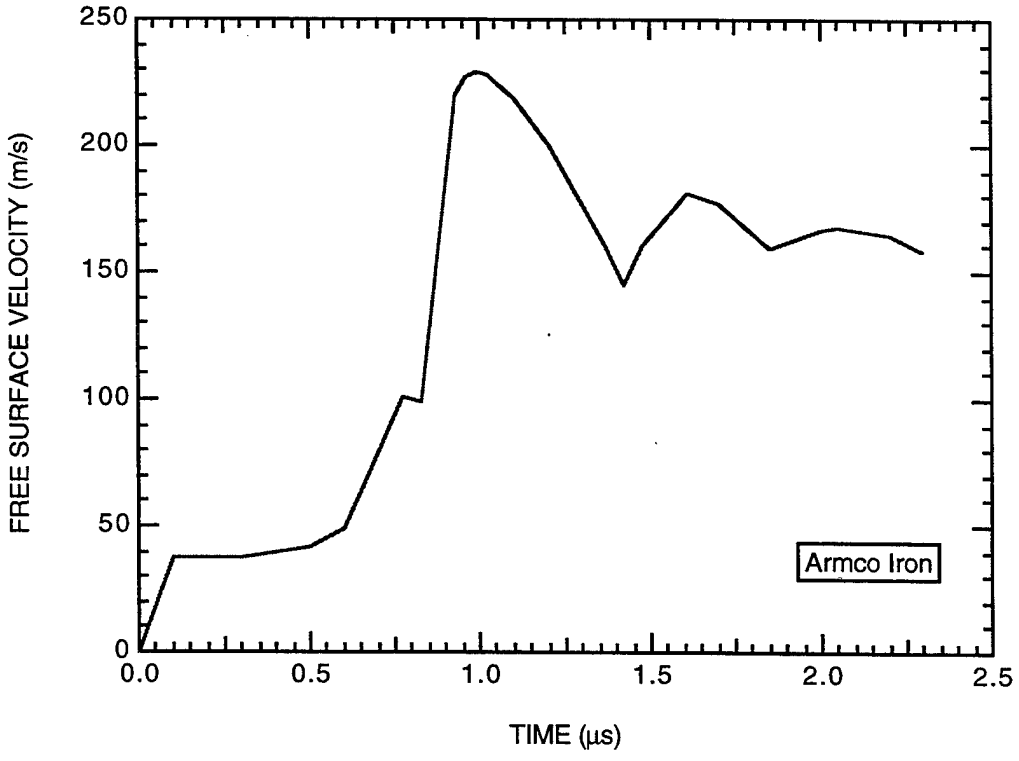
Armco Iron	
Density	7.80 g/cm^3
Bulk sound velocity	4.65 mm/μs
Longitudinal sound velocity	5.97 mm/μs



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	590±20 m/s
Flyer plate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Armco iron (rod) 20 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness[1]	1.49±0.09 GPa 1.2 mm (±10%)

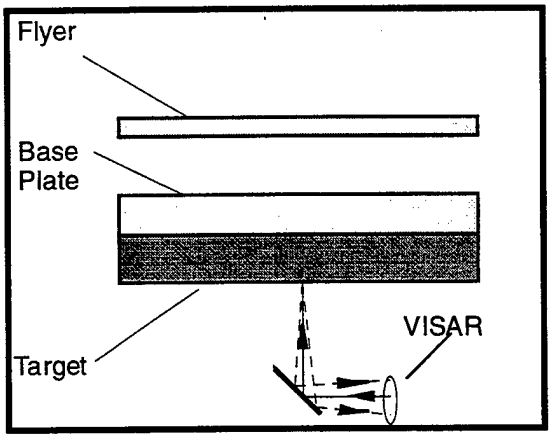
Reference: Kanel and Shcherban (1980)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



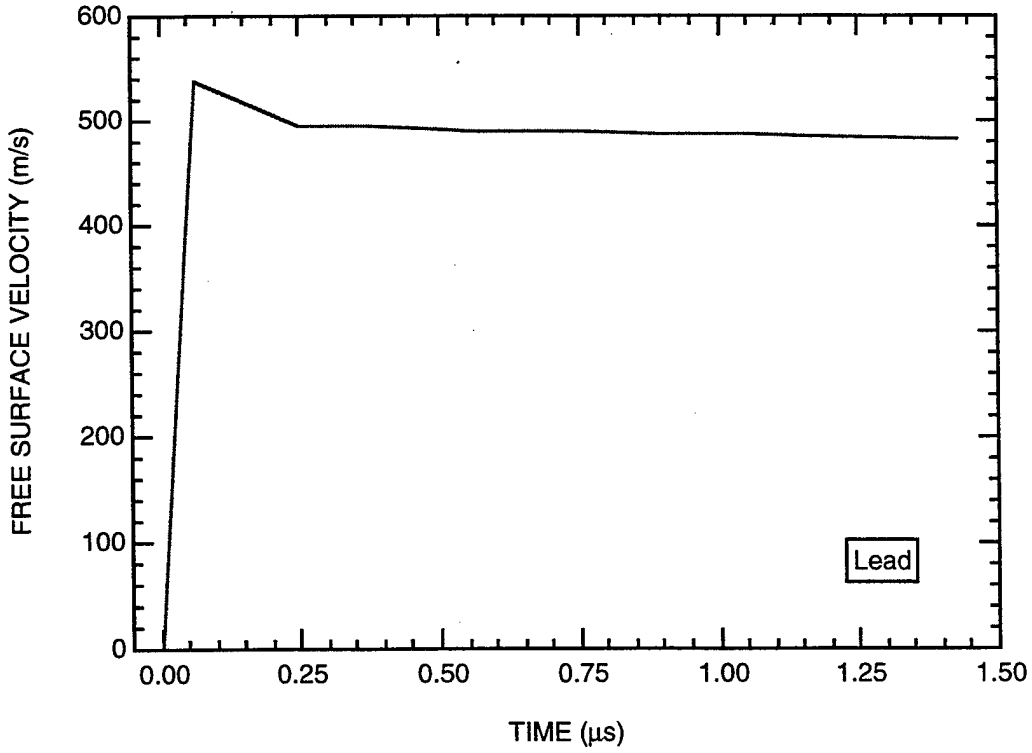
B.26 LEAD.

Lead	
Density	11.35 g/cm^3
Bulk sound velocity	2.03 mm/μs
Longitudinal sound velocity	2.25 mm/μs

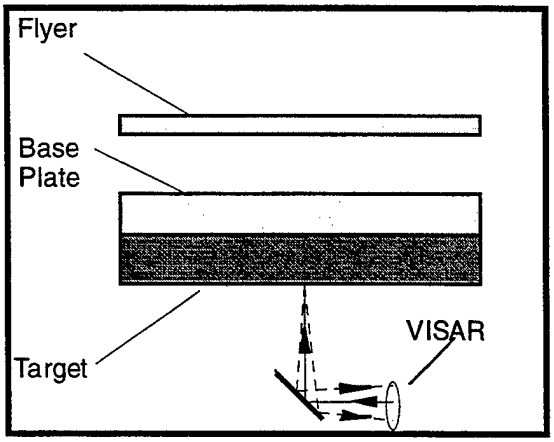


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	700±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4.53 mm
Target: - material - thickness	Lead (pressed) 3.75 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	0.5 Gpa (±6%)

Reference: Kanel et al. (1996)

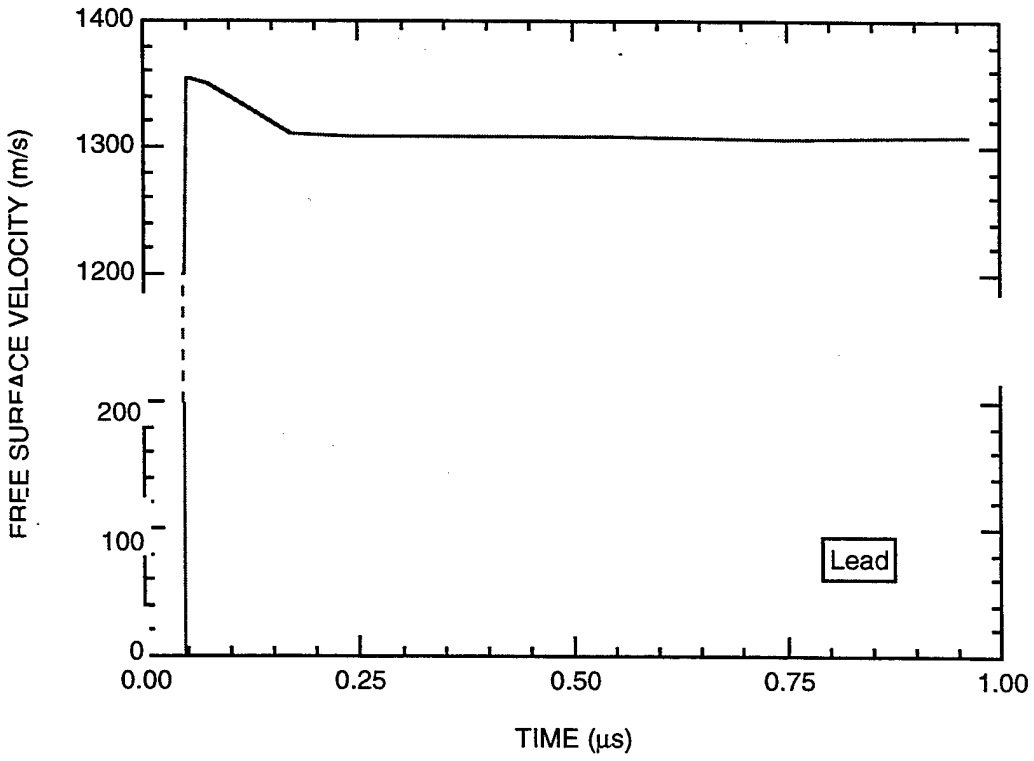


Lead	
Density	11.35 g/cm^3
Bulk sound velocity	2.03 mm/μs
Longitudinal sound velocity	2.25 mm/μs

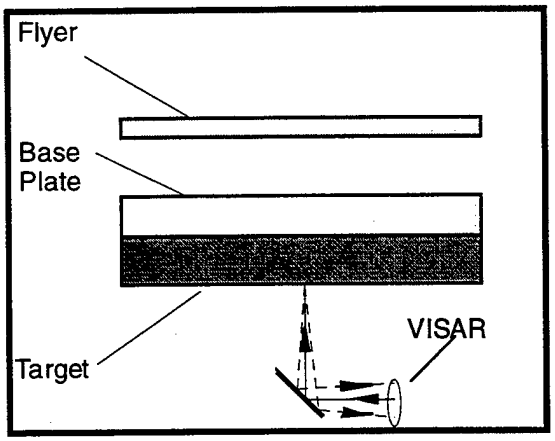


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	2000±70 m/s
Flyer plate: - material - thickness	Aluminum 1.9 mm
Baseplate: - material - thickness	Aluminum 4 mm
Target: - material - thickness	Lead (pressed) 3.75 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	0.5 GPa (±6%)

Reference: Kanel et al. (1996)

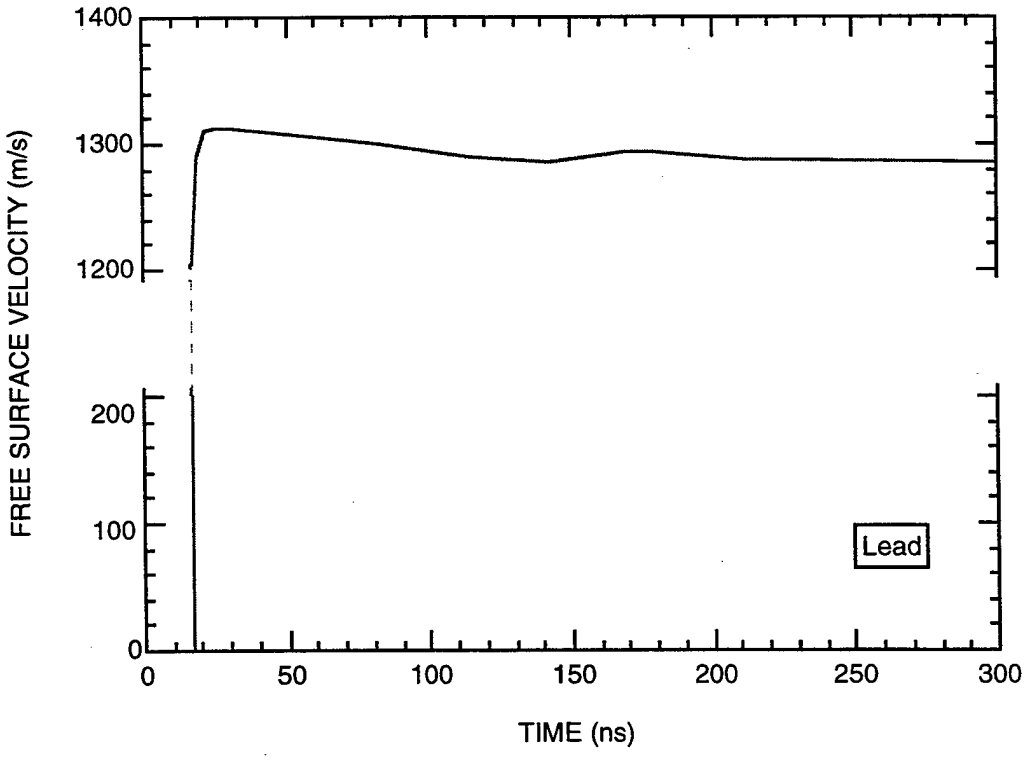


Lead	
Density	11.35 g/cm^3
Bulk sound velocity	2.03 mm/μs
Longitudinal sound velocity	2.25 mm/μs



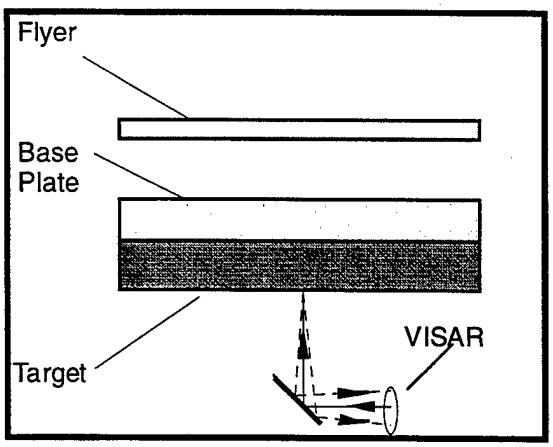
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4.1 mm
Target: - material - thickness	Lead (pressed) 4.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	0.35 GPa (±6%)

Reference: Kanel et al. (1996)



B.27 TIN.

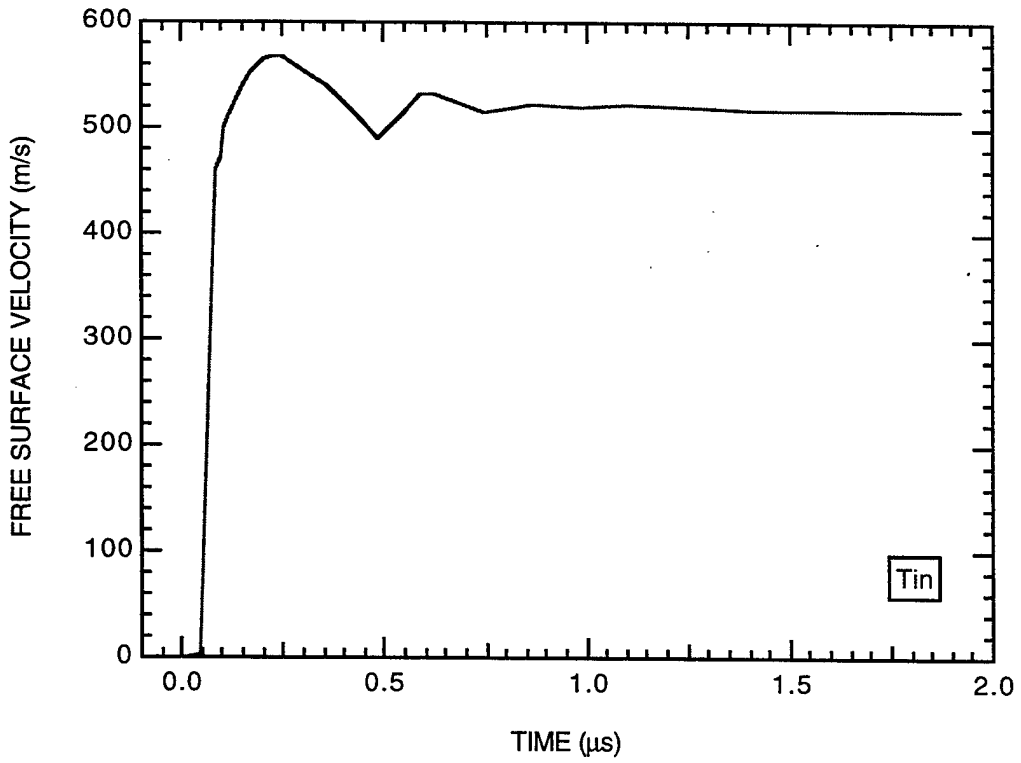
Tin	
Density	7.29 g/cm^3
Bulk sound velocity	2.61 mm/μs
Longitudinal sound velocity	3.43 mm/μs



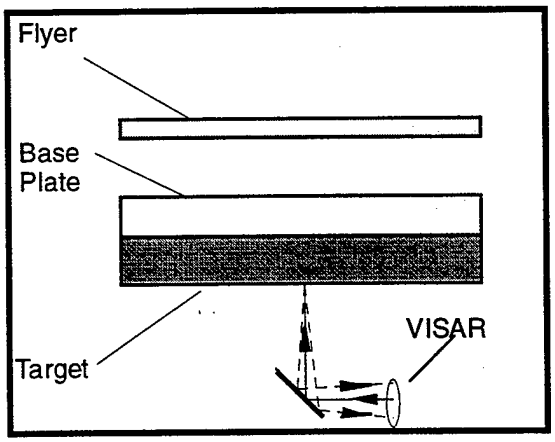
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.0 mm
Baseplate: - material - thickness	Aluminum 4 mm
Target: - material - thickness	Tin 4.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.7±0.05 Gpa 0.44 mm (±10%)

Reference: Kanel et al. (1996)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.

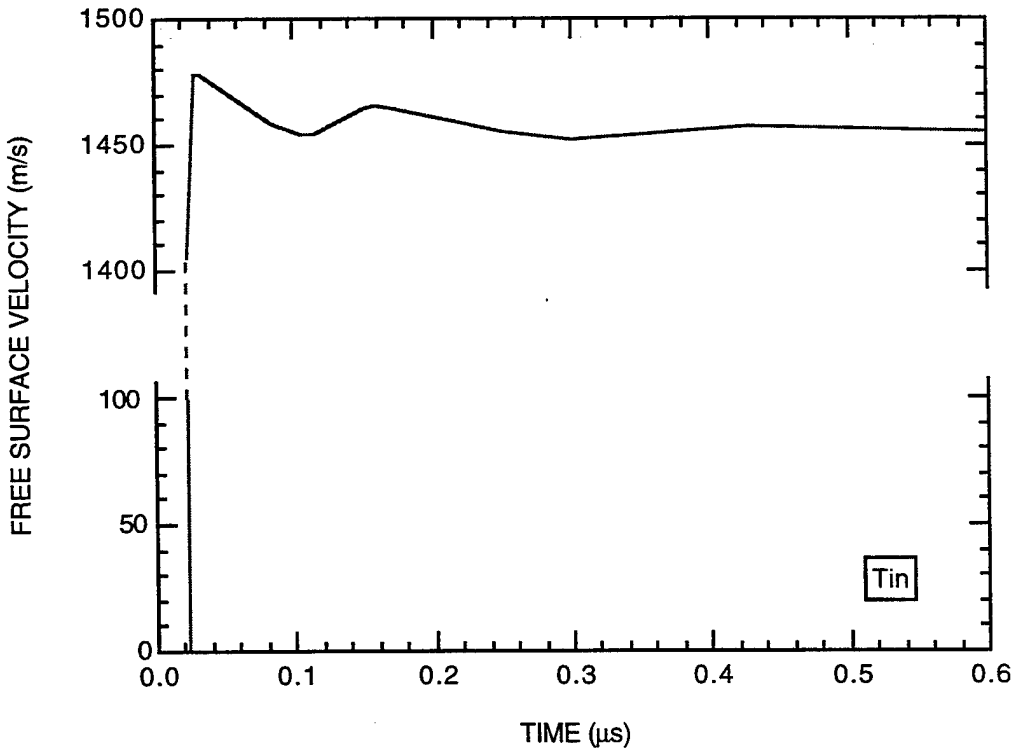


Tin	
Density	7.29 g/cm^3
Bulk sound velocity	2.61 mm/μs
Longitudinal sound velocity	3.43 mm/μs



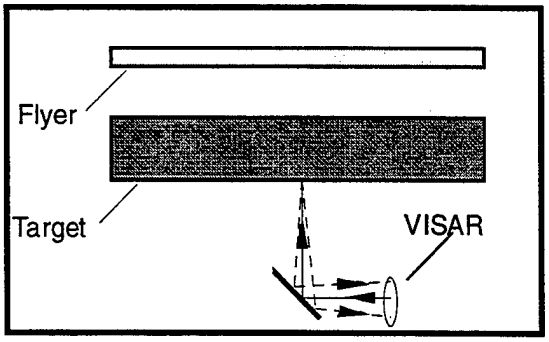
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	2000±70 m/s
Flyer plate: - material - thickness	Aluminum 1.8 mm
Baseplate: - material - thickness	Aluminum 4.95 mm
Target: - material - thickness	Tin 5.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	0.22±0.02 GPa

Reference: Kanel et al. (1996)



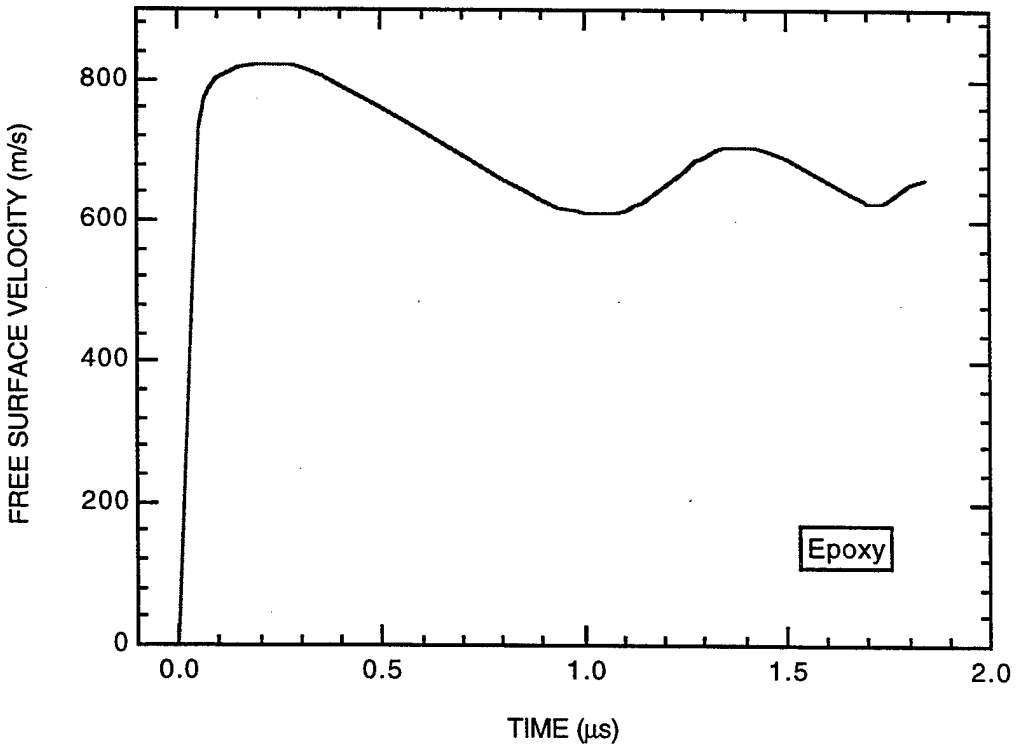
B.28 EPOXY.

Epoxy EDT-10	
Density	1.2 g/cm^3
Longitudinal sound velocity	2.62 mm/μs



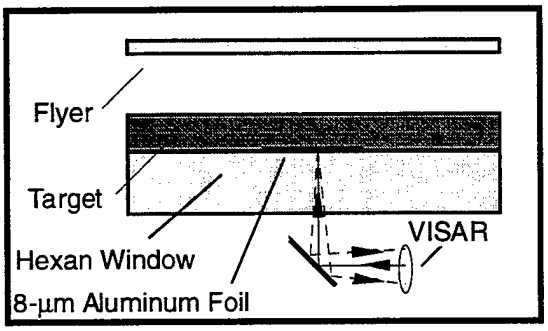
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 1.4 mm
Target: - material - thickness	Epoxy - 10 4.5 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.3±0.05 GPa 0.9 mm (±10%)

[1] Determined based on the period of oscillation in the measured free-surface velocity history.



B.29 PMMA.

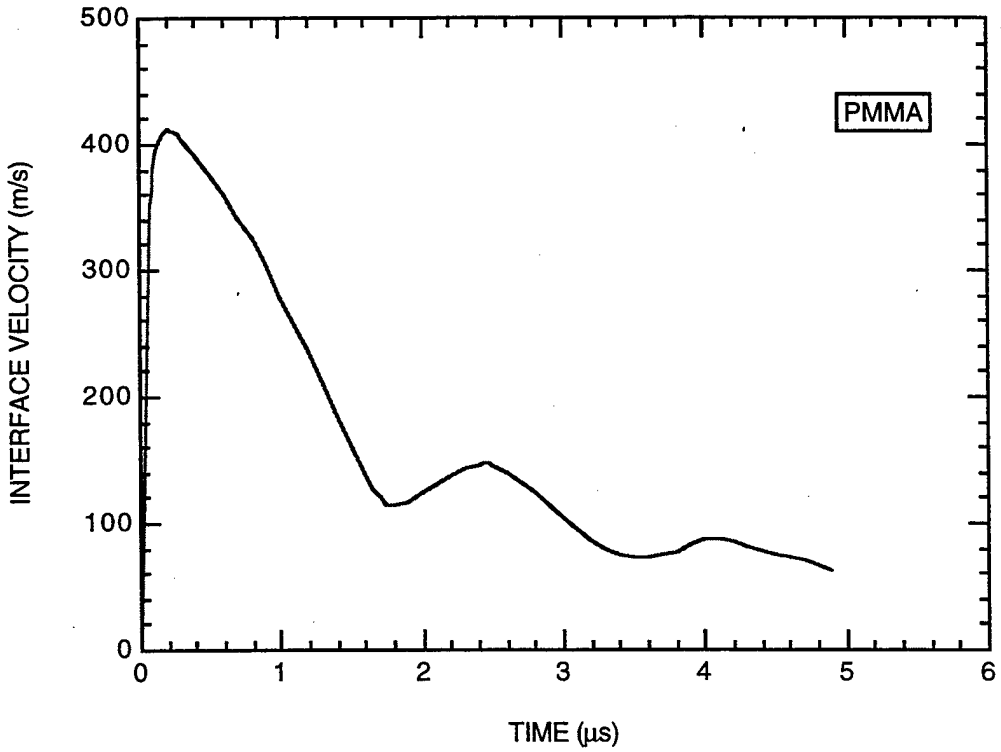
PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs



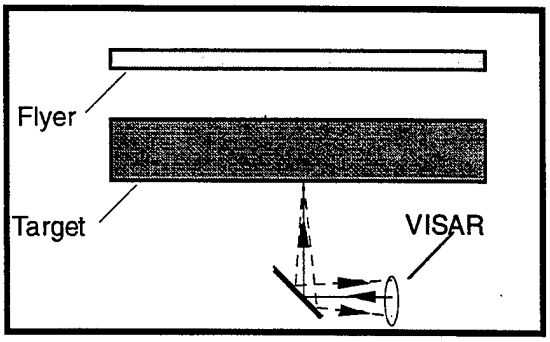
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 1.33 mm
Target: - material - thickness	PMMA 11.5 mm
Measurement technique	VISAR (with hexan window)
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.17±0.01 GPa 2.8 mm (±10%)

Reference: Parhomenko and Utkin (1990)

[1] Determined based on the period of oscillation in the measured velocity history.



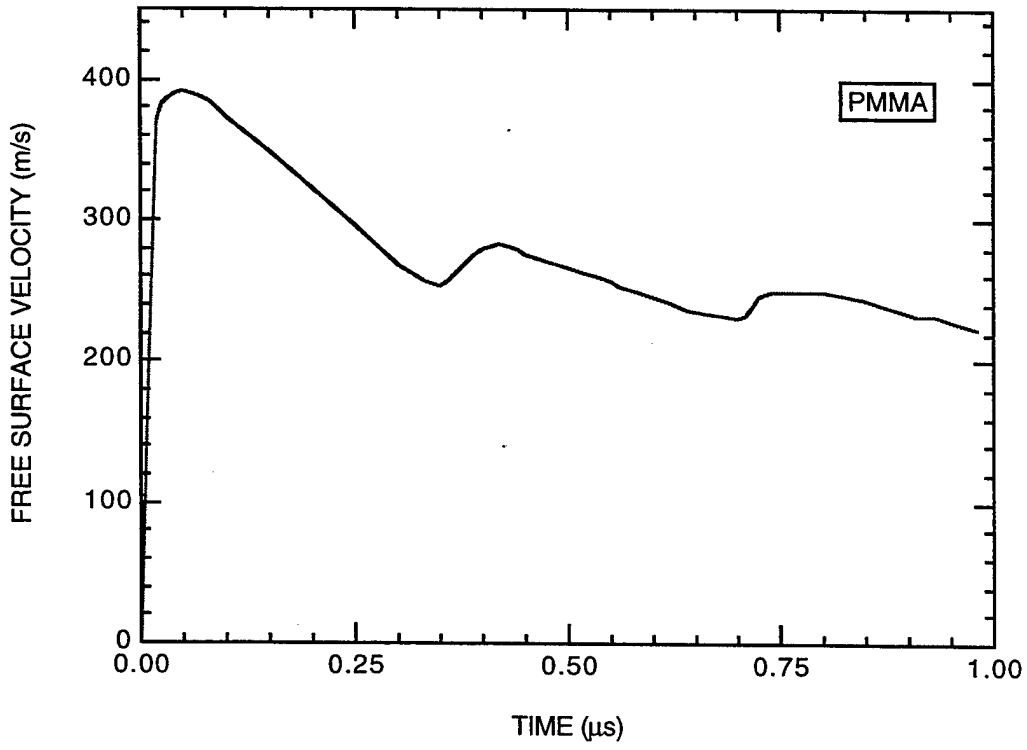
PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs



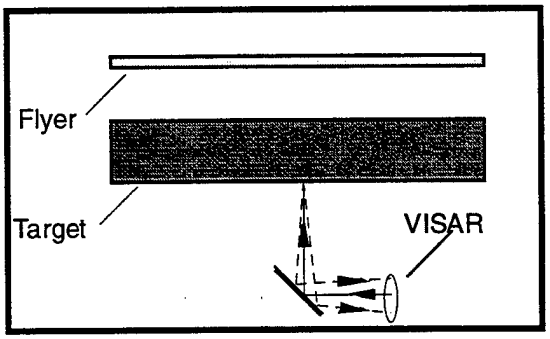
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	PMMA 8.32 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.21±0.01 GPa 0.46 mm (±10%)

Reference: Parhomenko and Utkin (1990)

[1] Determined based on the period of oscillation in the measured velocity history.



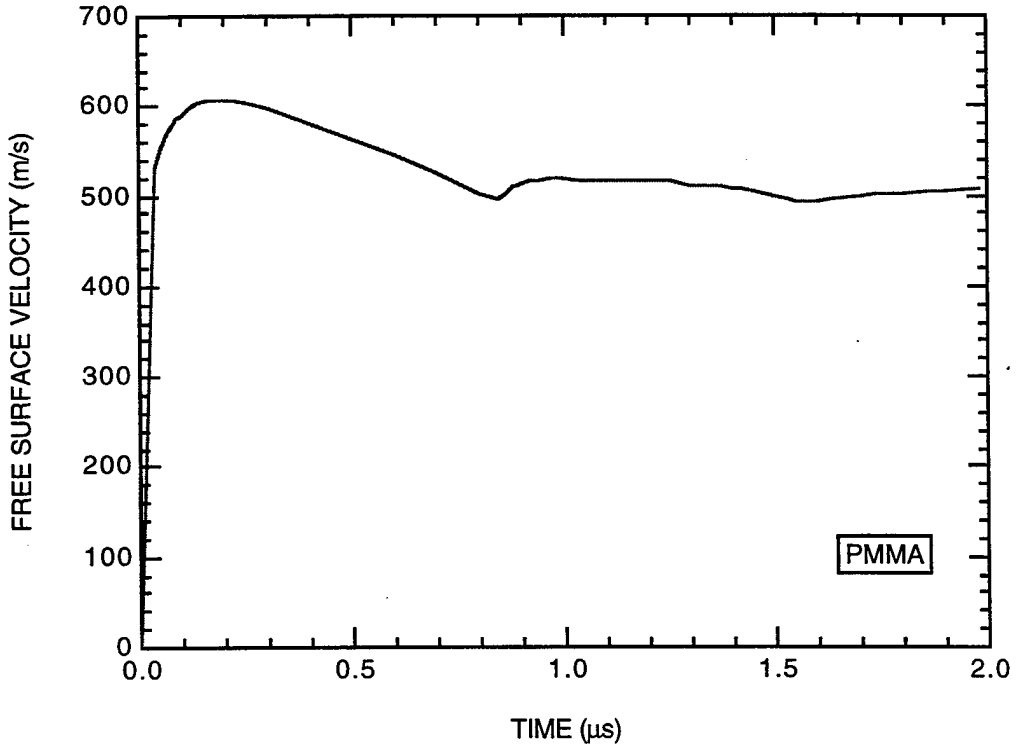
PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs



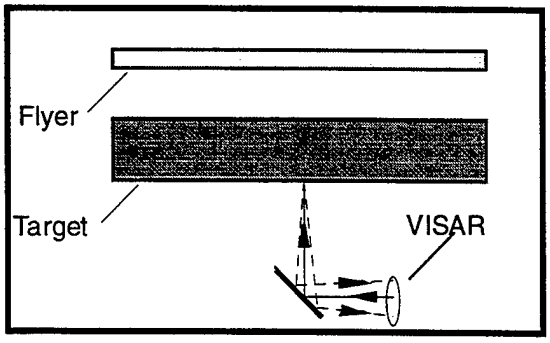
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 1.36 mm
Target: - material - thickness	PMMA 11.68 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.17±0.01 GPa 0.86 mm (±10%)

Reference: Parhomenko and Utkin (1990)

[1] Determined based on the period of oscillation in the measured velocity history.

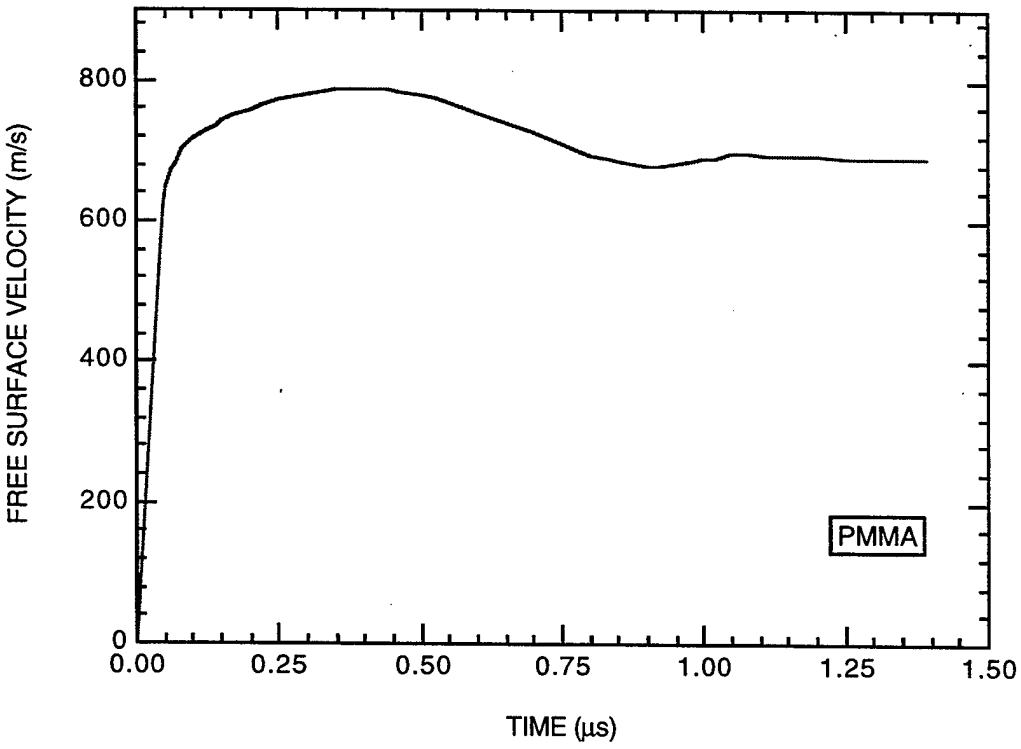


PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs

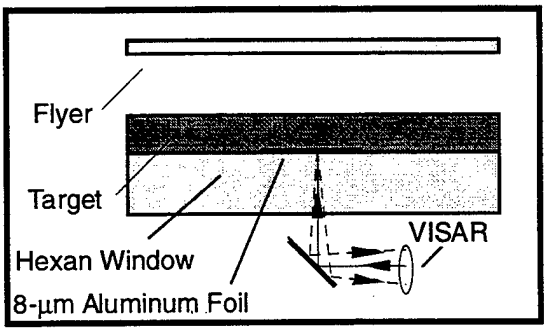


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 2.16 mm
Target: - material - thickness	PMMA 8.30 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.18±0.02 GPa Not determined

Reference: Parhomenko and Utkin (1990)

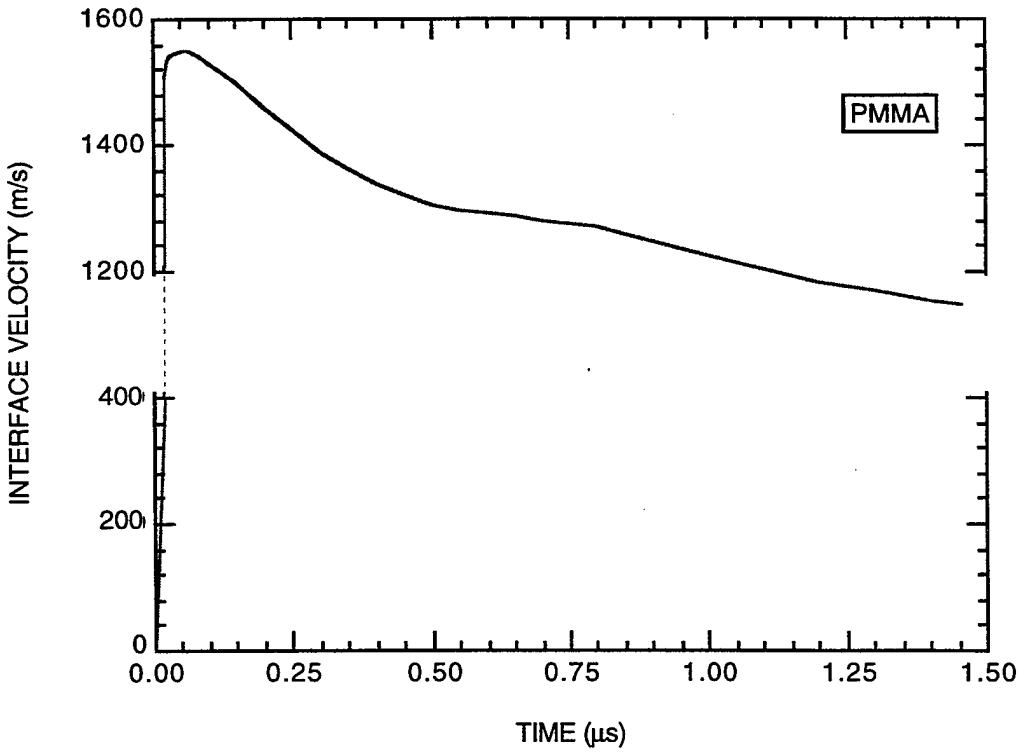


PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs

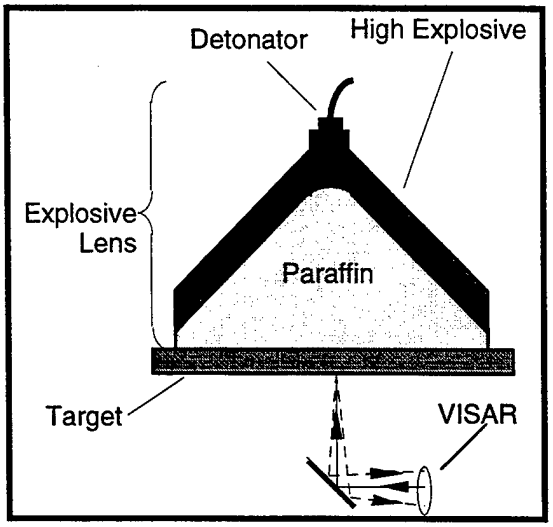


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	PMMA 8.2 mm
Measurement technique	VISAR (hexan window)
Measurement accuracy	±5 m/s
Spall strength	Not determined

Reference: Parhomenko and Utkin (1990)



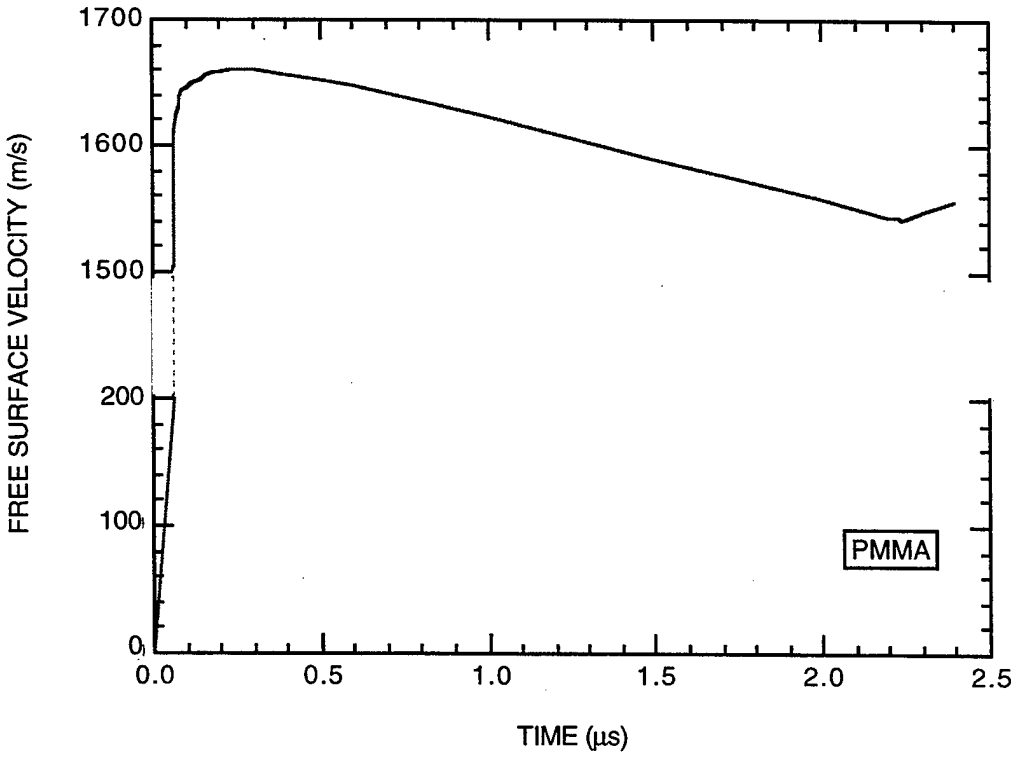
PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs



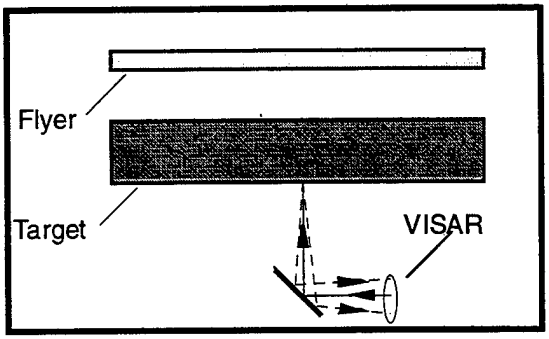
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	PMMA 18.21 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness[1]	0.17±0.01 GPa 2.85 mm (±10%)

Reference: Parhomenko and Utkin (1990)

[1] Determined based on the period of oscillation in the measured free surface velocity history.

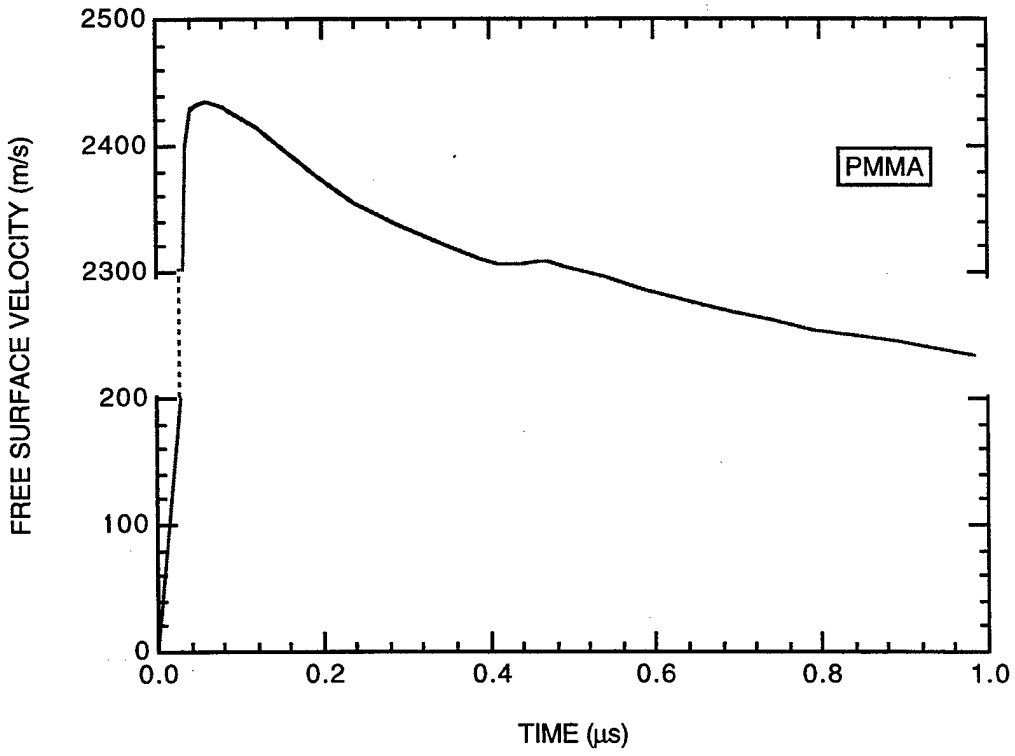


PMMA	
Density	1.186 g/cm^3
Bulk sound velocity	2.65 mm/μs
Longitudinal sound velocity	2.72 mm/μs



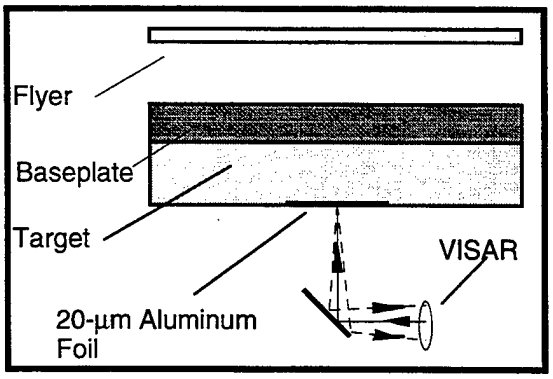
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1900±70 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	PMMA 8.28 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	0.21±0.015 GPa

Reference: Parhomenko and Utkin (1990)



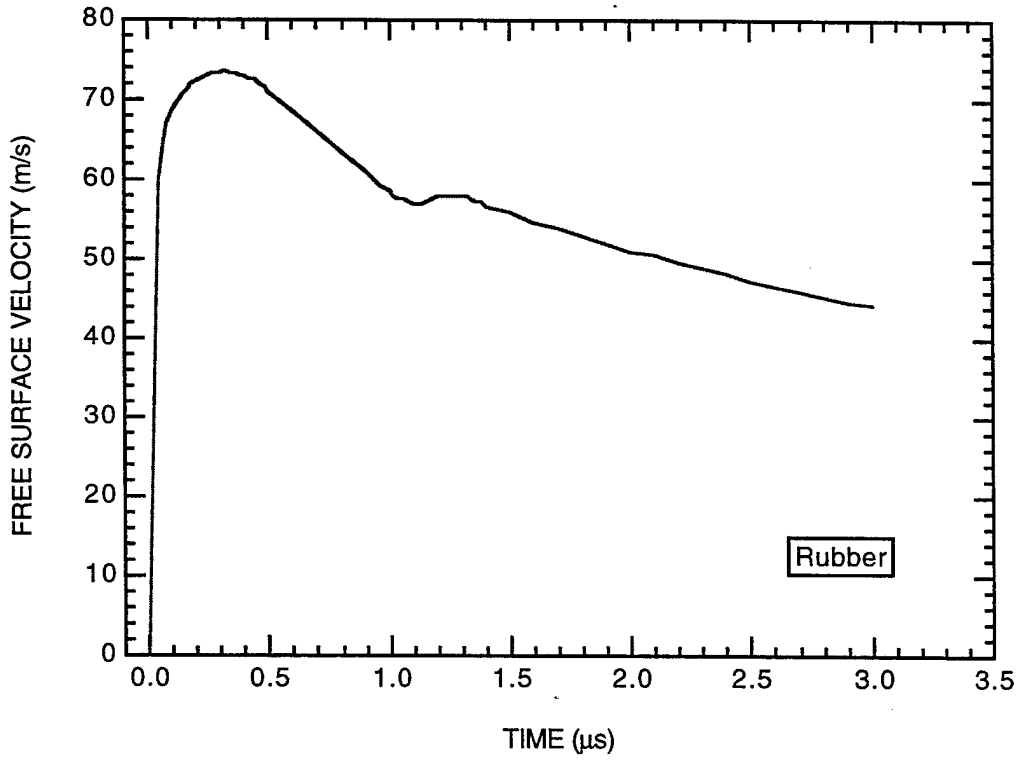
B.30 RUBBER.

White Rubber (Grade 7889)	
Density	1.34 g/cm^3
Bulk sound velocity	1.50 mm/μs

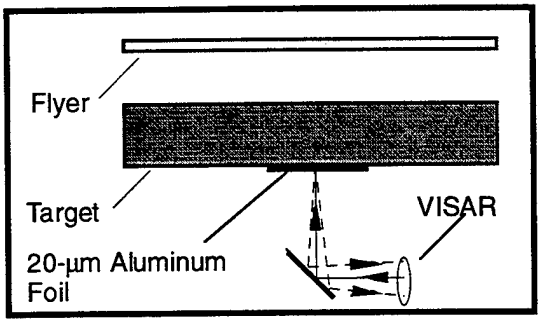


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	380±20 m/s
Flyer plate: - material - thickness	PMMA 1.5 mm
Baseplate: - material - thickness	Copper 5.0 mm
Target: - material - thickness	White rubber 10.4 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.016 GPa None observed at 100X magnification

Reference: Kalmykov et al. (1990)

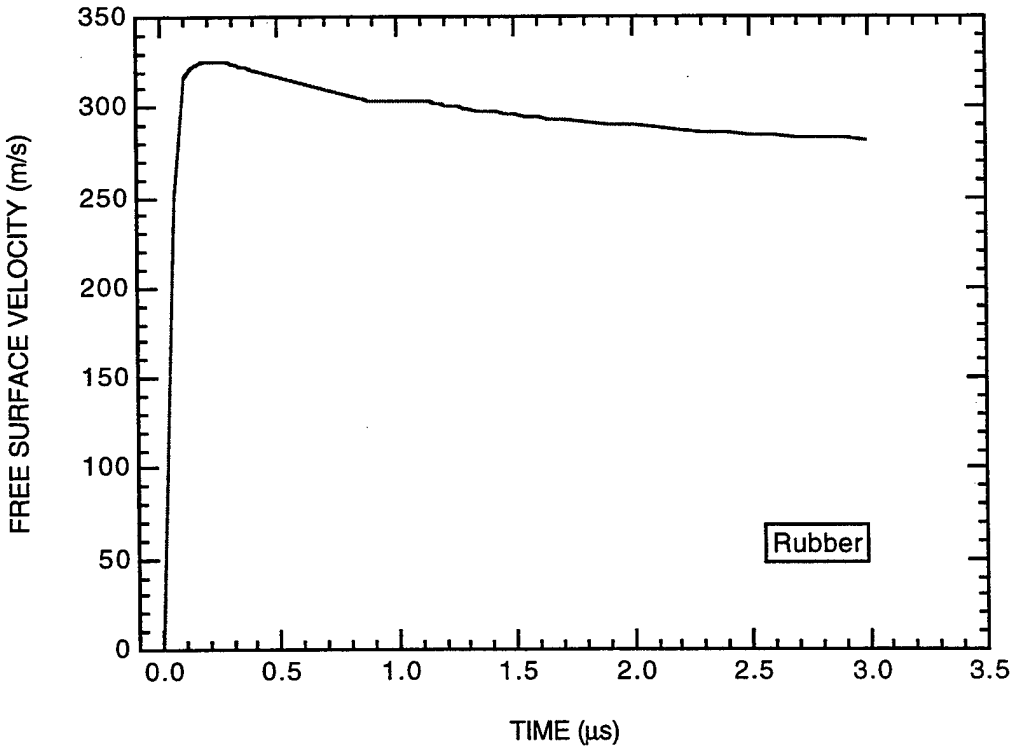


White Rubber (Grade 7889)	
Density	1.34 g/cm^3
Bulk sound velocity	1.50 mm/μs

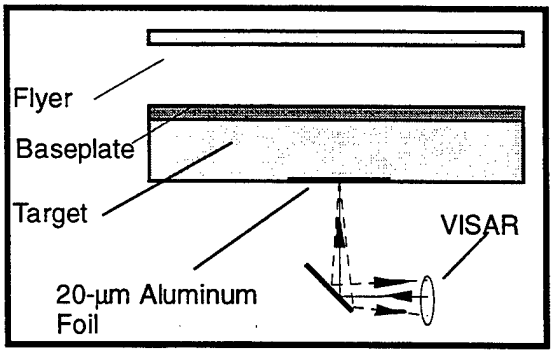


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	380±20 m/s
Flyer plate: - material - thickness	PMMA 1.5 mm
Target: - material - thickness	White rubber 9.95 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.022 GPa None observed at 100X magnification

Reference: Kalmykov et al. (1990)

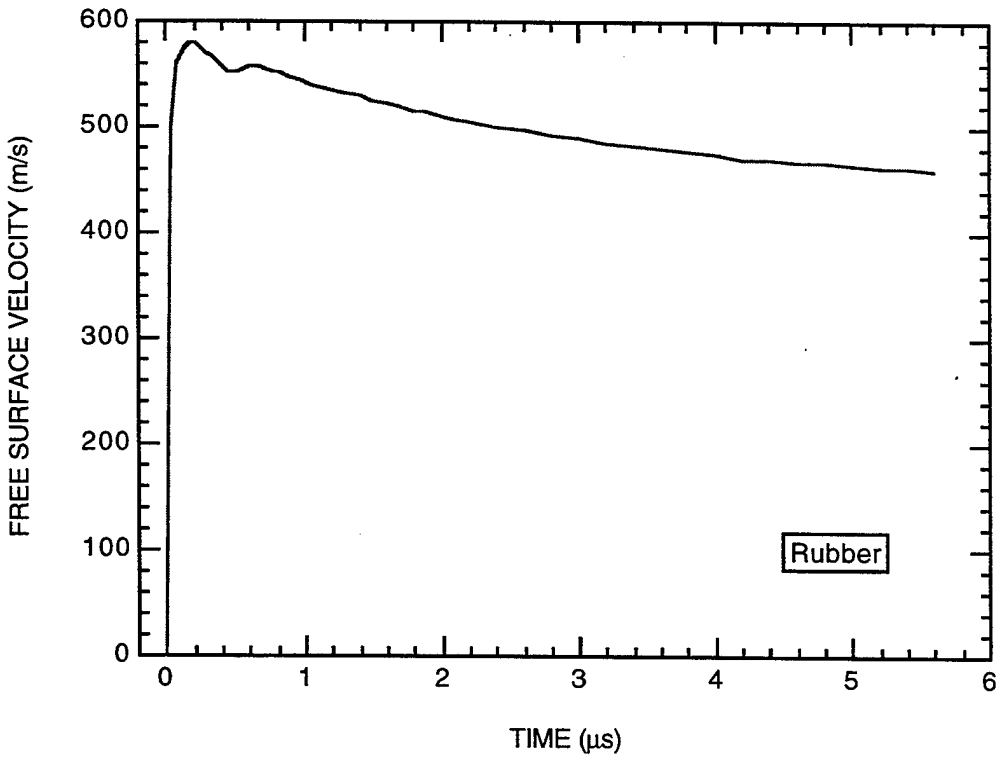


White Rubber (Grade 7889)	
Density	1.34 g/cm^3
Bulk sound velocity	1.50 mm/μs

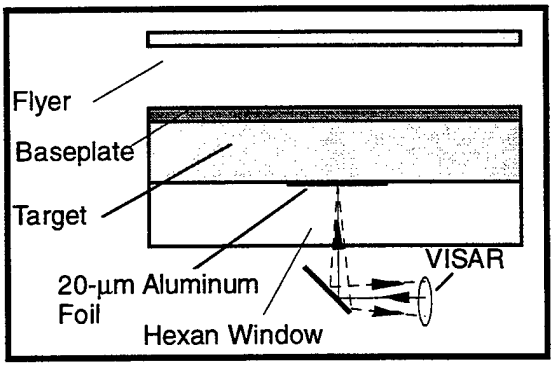


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 2.3 mm
Baseplate: - material - thickness	PMMA 1.9 mm
Target: - material - thickness	Filled rubber 10.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.027 GPa None observed at 100X magnification

Reference: Kalmykov et al. (1990)

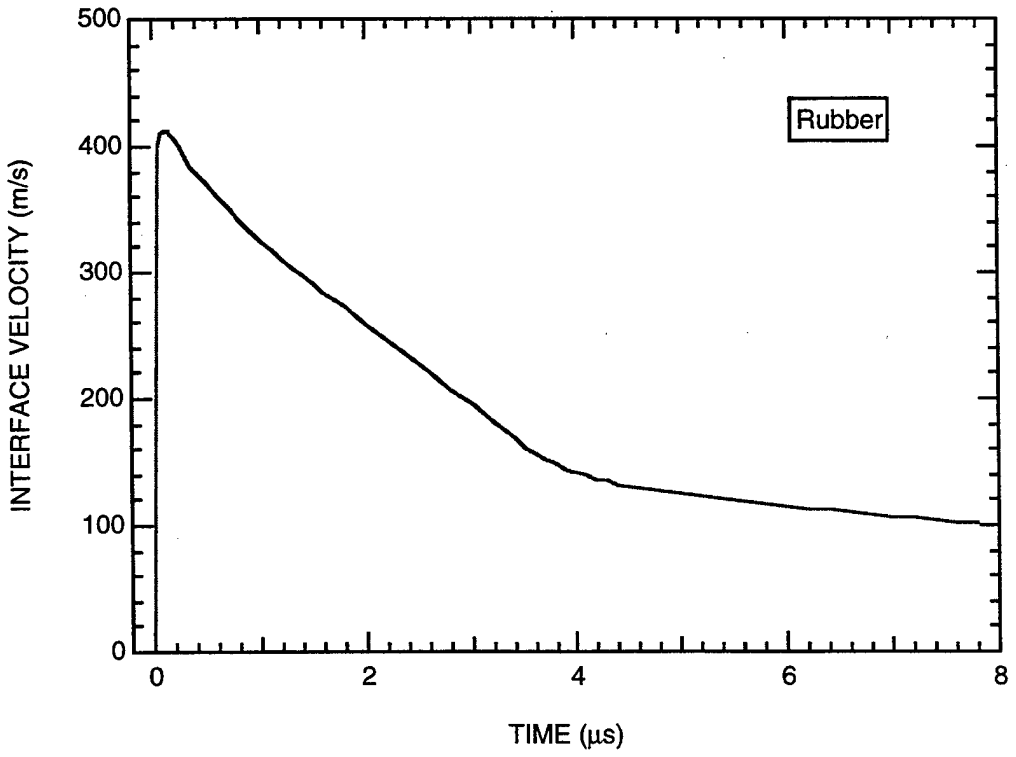


White Rubber (Grade 7889)	
Density	1.34 g/cm^3
Bulk sound velocity	1.50 mm/μs

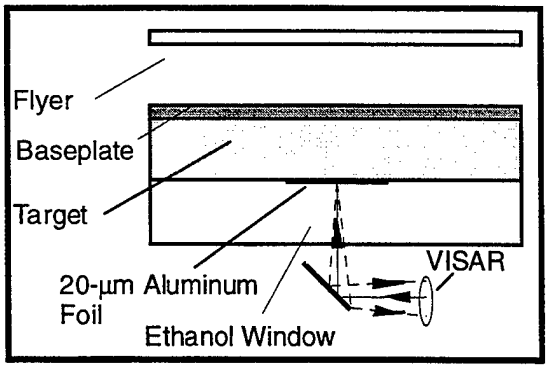


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 2.40 mm
Baseplate: - material - thickness	PMMA 2.02 mm
Target: - material - thickness	Filled rubber 9.68 mm
Measurement technique	VISAR (with hexan window)
Measurement accuracy	±5 m/s
Spall strength	Not determined

Reference: Kalmykov et al. (1990)

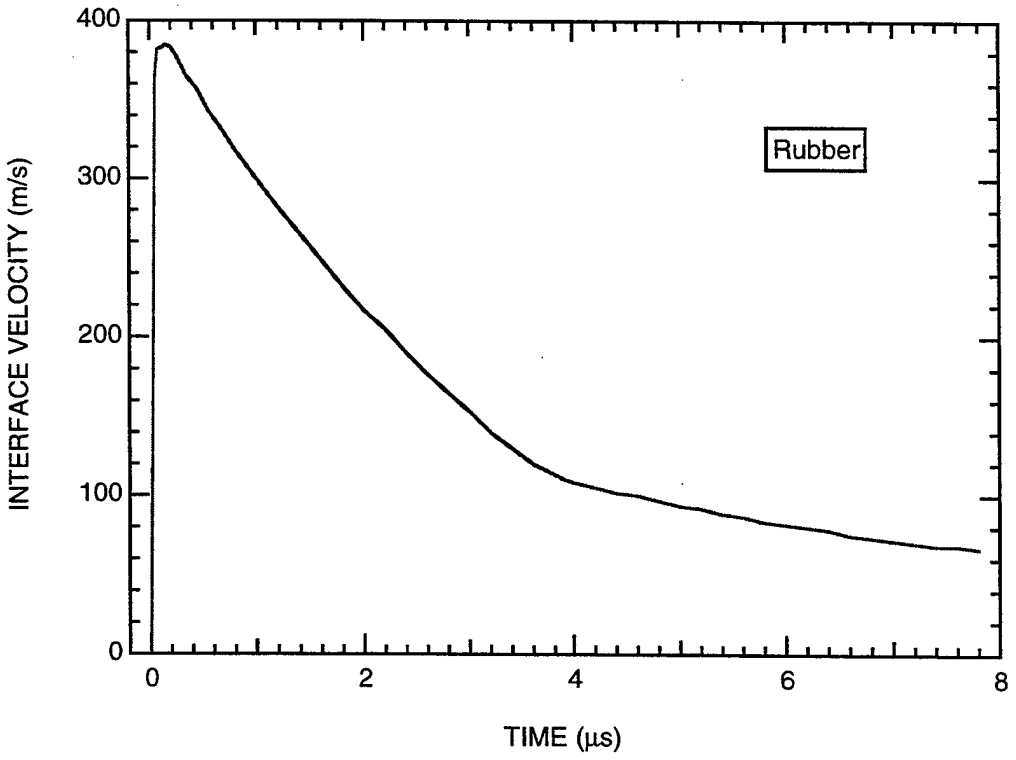


White Rubber (Grade 7889)	
Density	1.34 g/cm^3
Bulk sound velocity	1.50 mm/μs



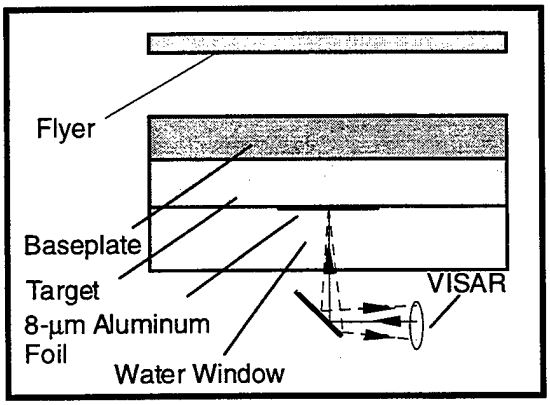
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 2.15 mm
Baseplate: - material - thickness	PMMA 2.25 mm
Target: - material - thickness	Filled rubber 10.68 mm
Measurement technique	VISAR (with ethanol window)
Measurement accuracy	±5 m/s
Spall strength	Not determined

Reference: Kalmykov et al. (1990)



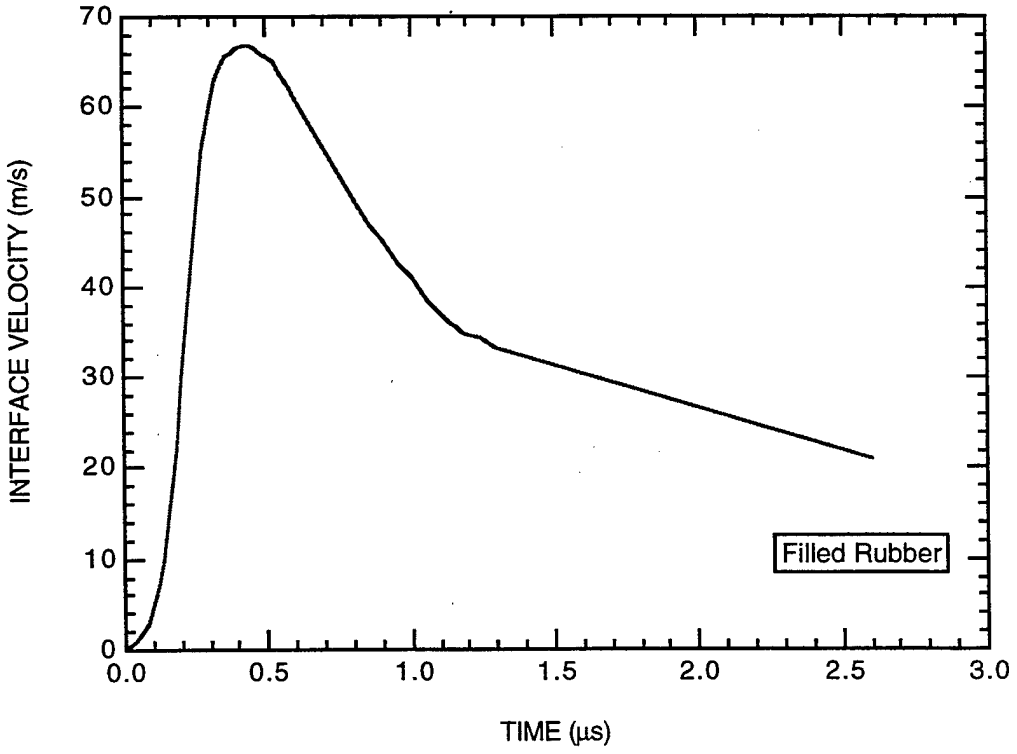
B.31 PROPELLANT SIMULANT (FILLED RUBBER).

Filled Rubber (Propellant Simulant)	
Density	1.60 g/cm^3
Bulk sound velocity	1.85 mm/μs
Type of rubber	Butadienenitride
Filler content	75% by mass (61.6% KCl)
Filler particle size	160-200 μm

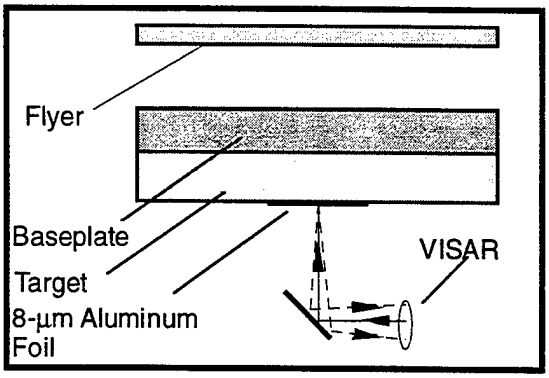


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	380±20 m/s
Flyer plate: - material - thickness	PMMA 1.6 mm
Baseplate: - material - thickness	Copper 5.03 mm
Target: - material - thickness	Filled rubber 4.5 mm
Measurement technique	VISAR (with water window)
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.01 GPa (±6%) None observed

Reference: Kanel et al. (1993c)

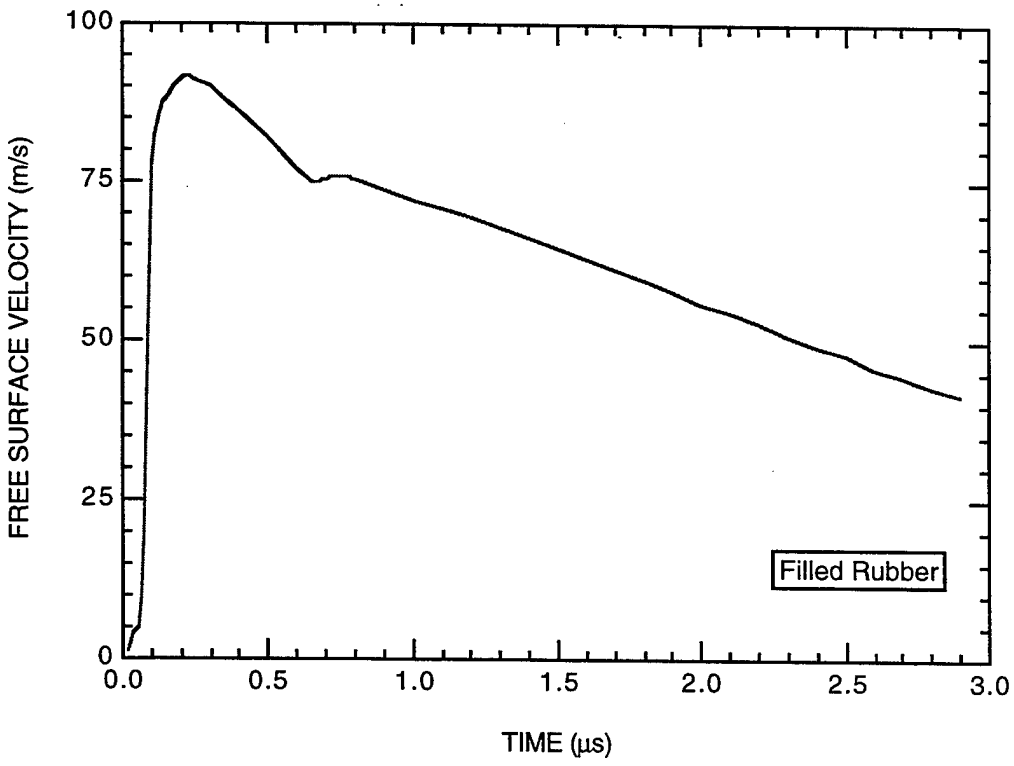


Filled Rubber (Propellant Simulant)	
Density	1.60 g/cm^3
Bulk sound velocity	1.85 mm/μs
Type of rubber	Butadienenitride
Filler content	75% by mass (61.6% KCl)
Filler particle size	20-50 μm

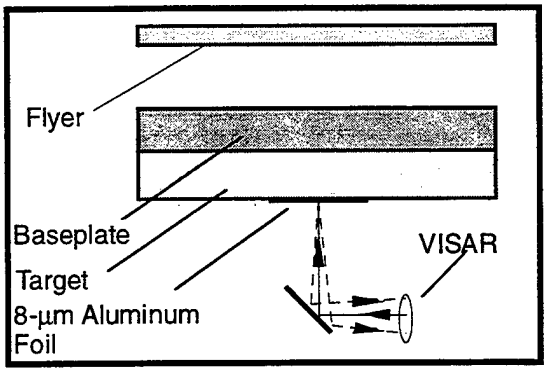


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	380±20 m/s
Flyer plate: - material - thickness	PMMA 1.7 mm
Baseplate: - material - thickness	Copper 5.0 mm
Target: - material - thickness	Filled rubber 4.8 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.025 GPa (±6%) None observed

Reference: Kanel et al. (1993c)

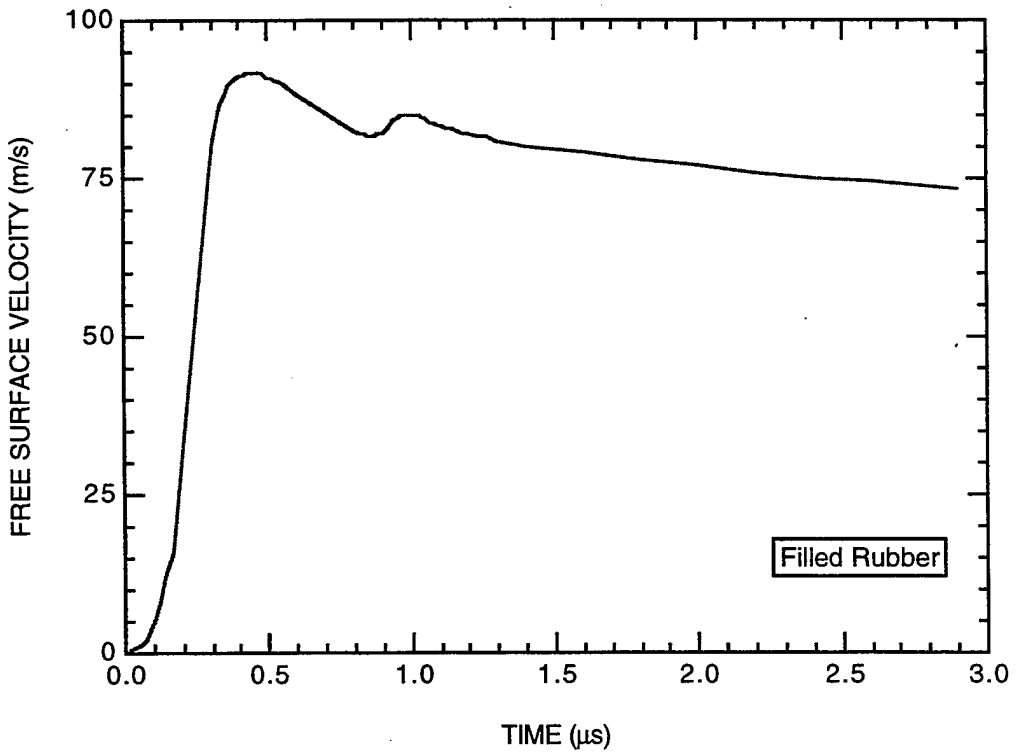


Filled Rubber (Propellant Simulant)	
Density	1.60 g/cm^3
Bulk sound velocity	1.85 mm/μs
Type of rubber	Butadienenitride
Filler content	75% by mass (61.6% KCl)
Filler particle size	160-200 μm

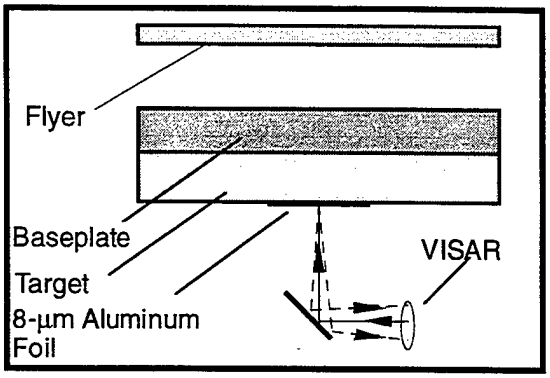


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	380±20 m/s
Flyer plate: - material - thickness	PMMA 1.72 mm
Baseplate: - material - thickness	Copper 5.0 mm
Target: - material - thickness	Filled rubber 4.63 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.015 GPa (±6%) None observed

Reference: Kanel et al. (1993c)

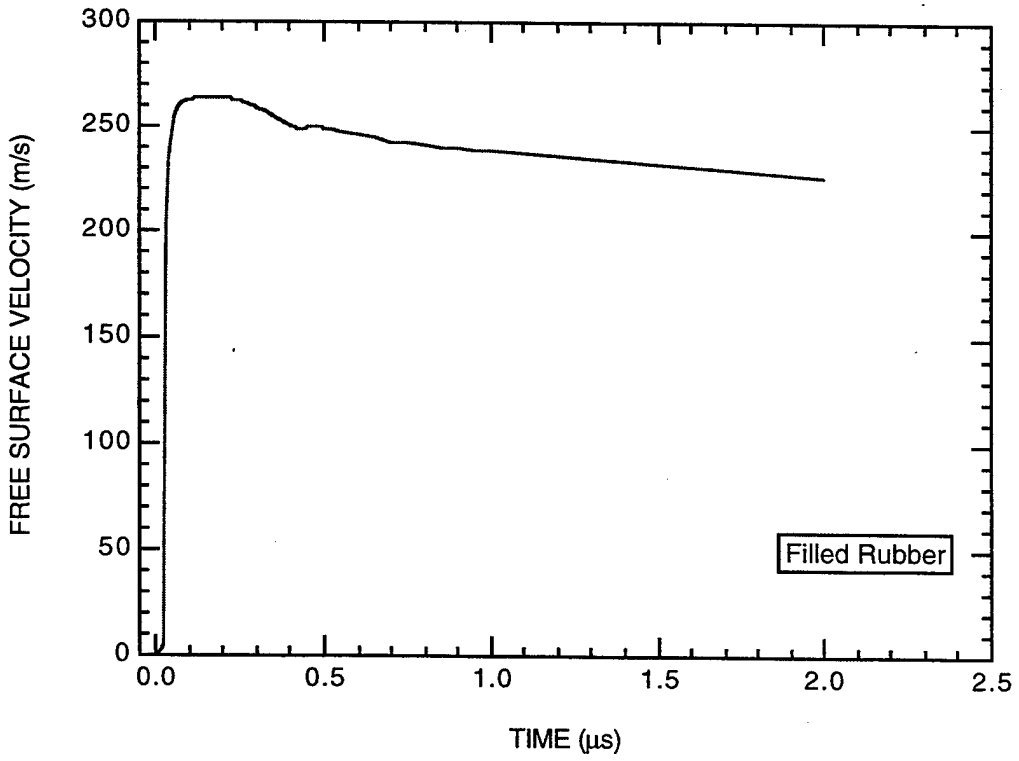


Filled Rubber (Propellant Simulant)	
Density	1.60 g/cm^3
Bulk sound velocity	1.85 mm/μs
Type of rubber	Butadienenitride
Filler content	75% by mass (61.6% KCl)
Filler particle size	20-50 μm

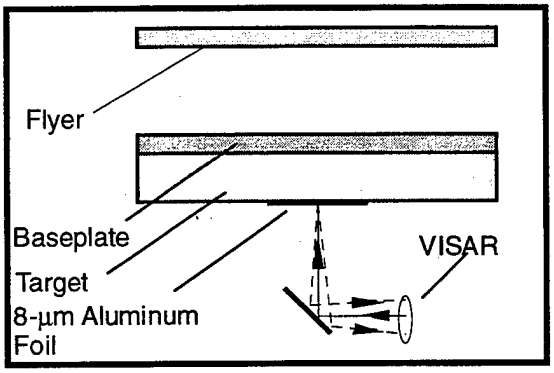


Experiment Summary	
Loading condition	1-D strain
Loading method	Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material	PMMA
- thickness	1.4 mm
Baseplate: - material	Copper
- thickness	5.0 mm
Target: - material	Filled rubber
- thickness	5.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	0.024 GPa (±6%)
Spall thickness	None observed

Reference: Kanel et al. (1993c)

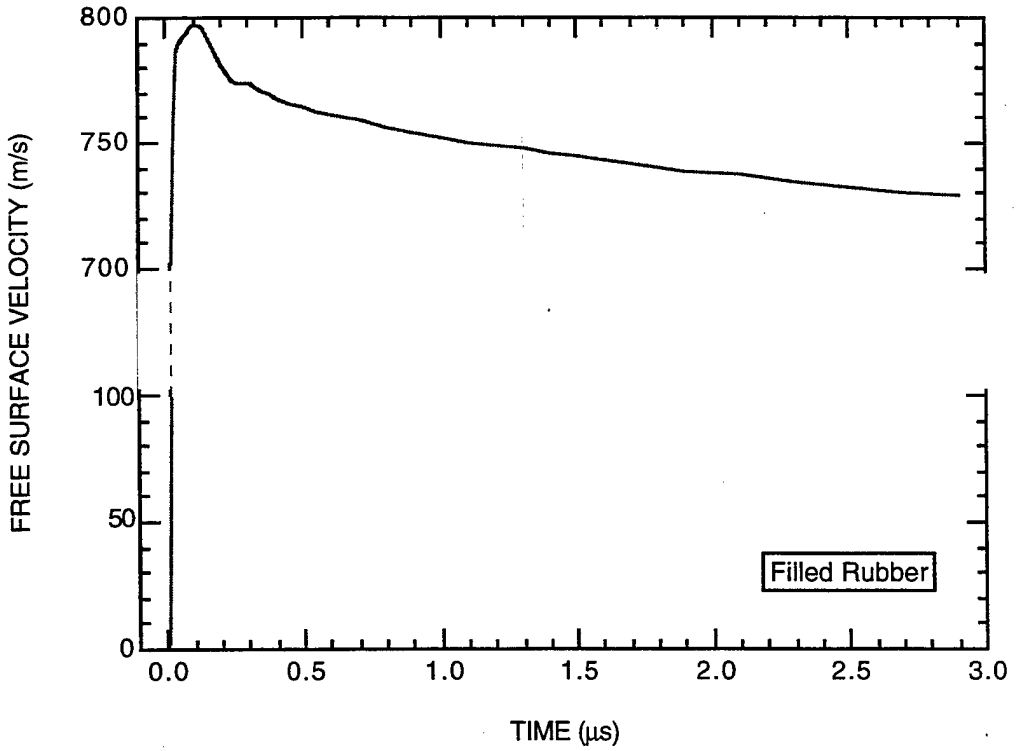


Filled Rubber (Propellant Simulant)	
Density	1.60 g/cm^3
Bulk sound velocity	1.85 mm/μs
Type of rubber	Butadienenitride
Filler content	75% by mass (61.6% KCl)
Filler particle size	20-50 μm



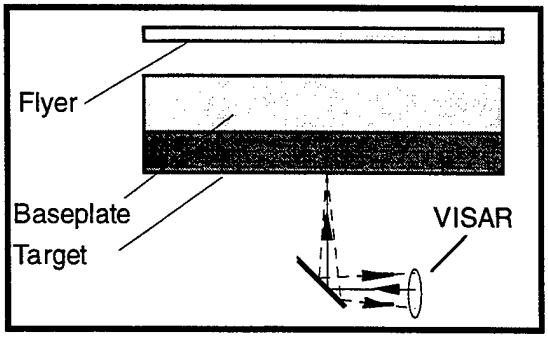
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	850±30 m/s
Flyer plate: - material - thickness	PMMA 1.4 mm
Baseplate: - material - thickness	PMMA 1.2 mm
Target: - material - thickness	Filled rubber 5.0 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Spall thickness	0.030 GPa (±6%) None observed

Reference: Kanel et al. (1993c)



B.32 ALUMINA.

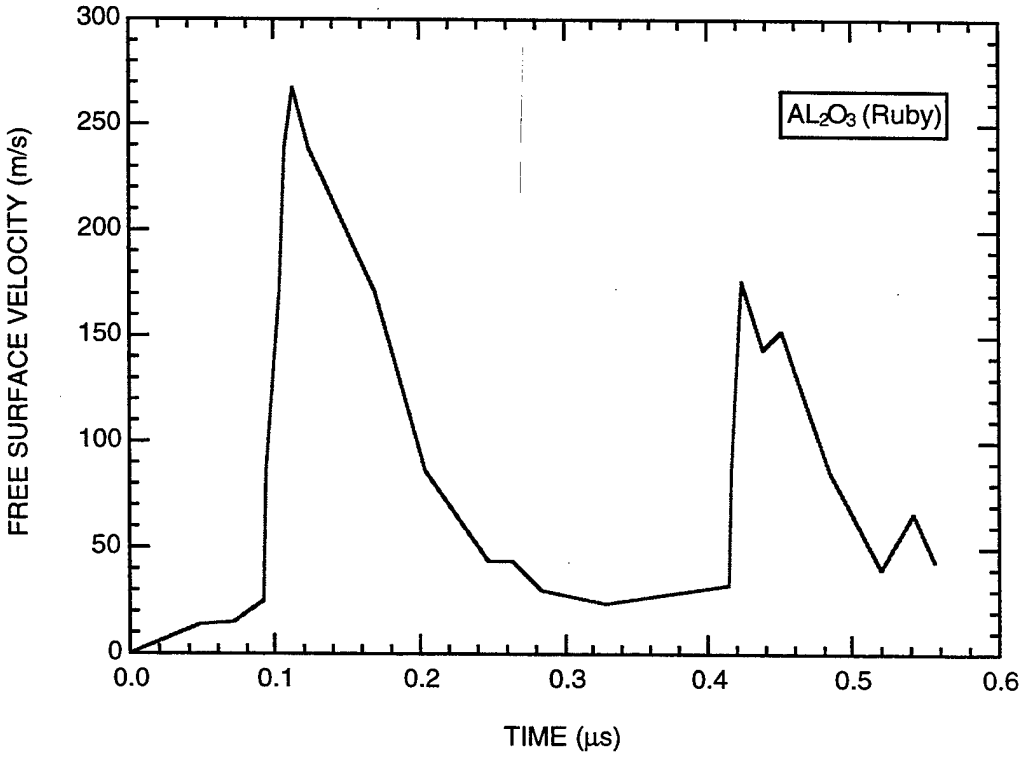
Alumina (Ruby)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs



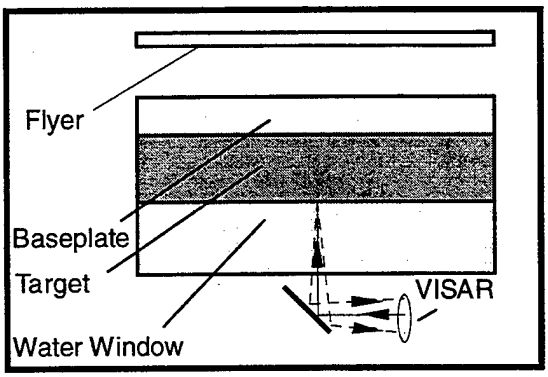
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Baseplate: - material - thickness	Aluminum 3 mm
Target: - material - thickness	Alumina (ruby)[1] 1.93 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength Peak stress Peak tensile stress	No spall 6.0 GPa 5.9 GPa

Reference: Kanel et al. (1993b)

[1] Loaded perpendicular to {1100}.



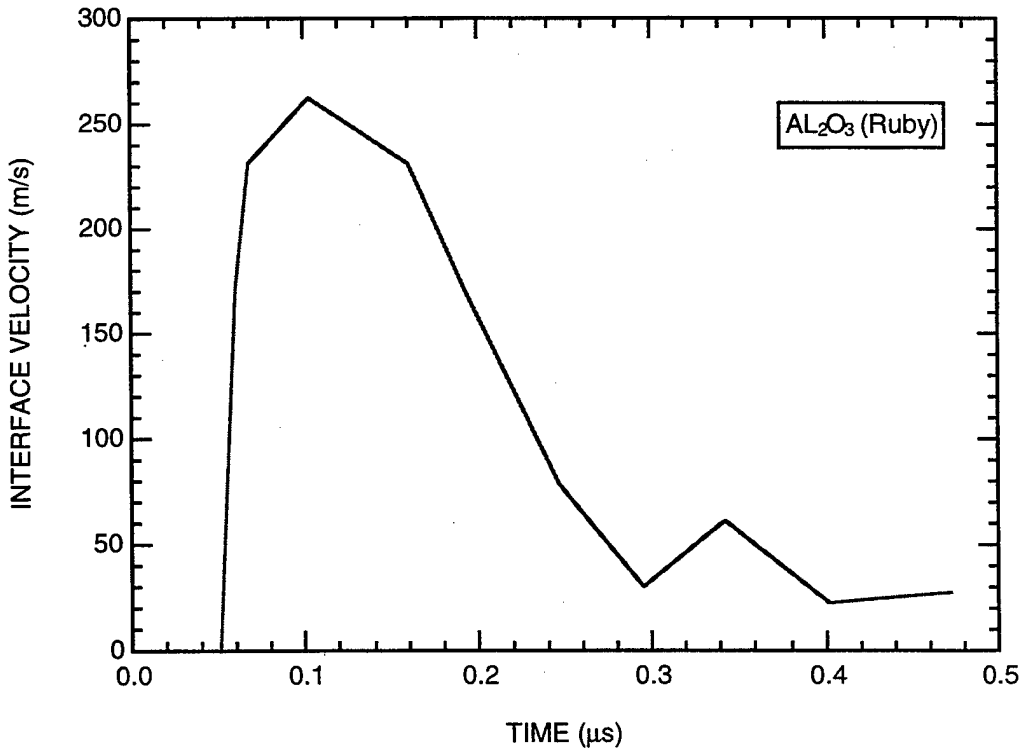
Alumina (Ruby)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs



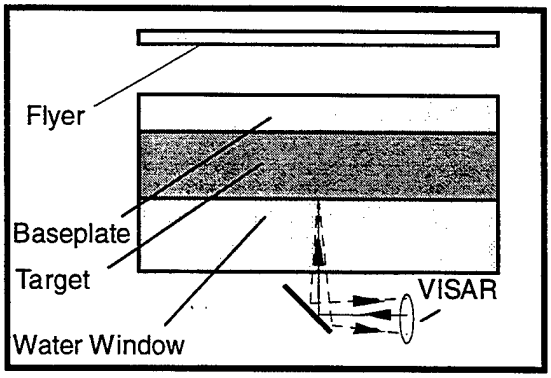
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2 mm
Target: - material - thickness	Alumina (ruby)[1] 4.98 mm
Measurement technique	VISAR (with water window)
Measurement accuracy	±5 m/s
Spall strength Peak stress Peak tensile stress	No spall 6.2 GPa 5.5 GPa

Reference: Kanel et al. (1993b)

[1] Loaded perpendicular to {1100}.



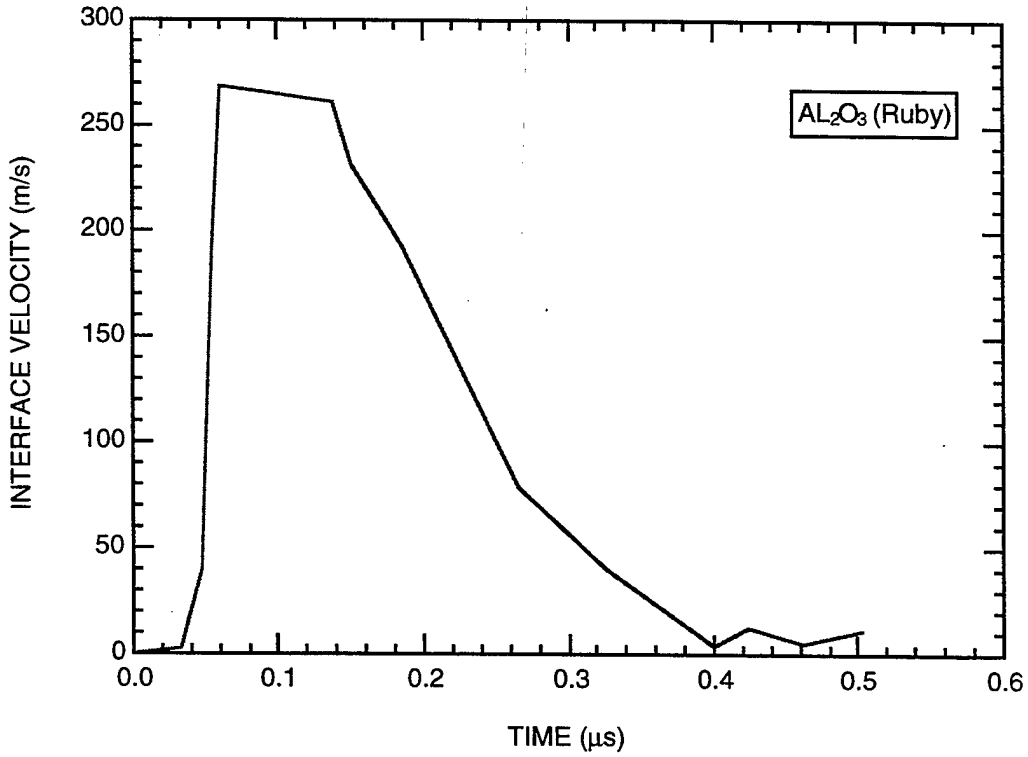
Alumina (Ruby)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs



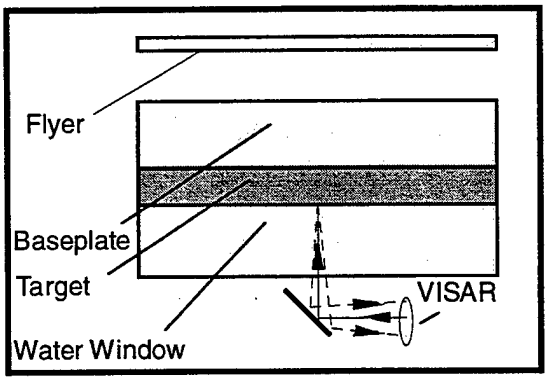
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 1.98 mm
Target: - material - thickness	Alumina (ruby)[1] 3.63 mm
Measurement technique	VISAR (with water window)
Measurement accuracy	±5 m/s
Spall strength Peak stress Peak tensile stress	No spall 6.3 GPa 5.6 GPa

Reference: Kanel et al. (1993b)

[1] Loaded perpendicular to {1120}.



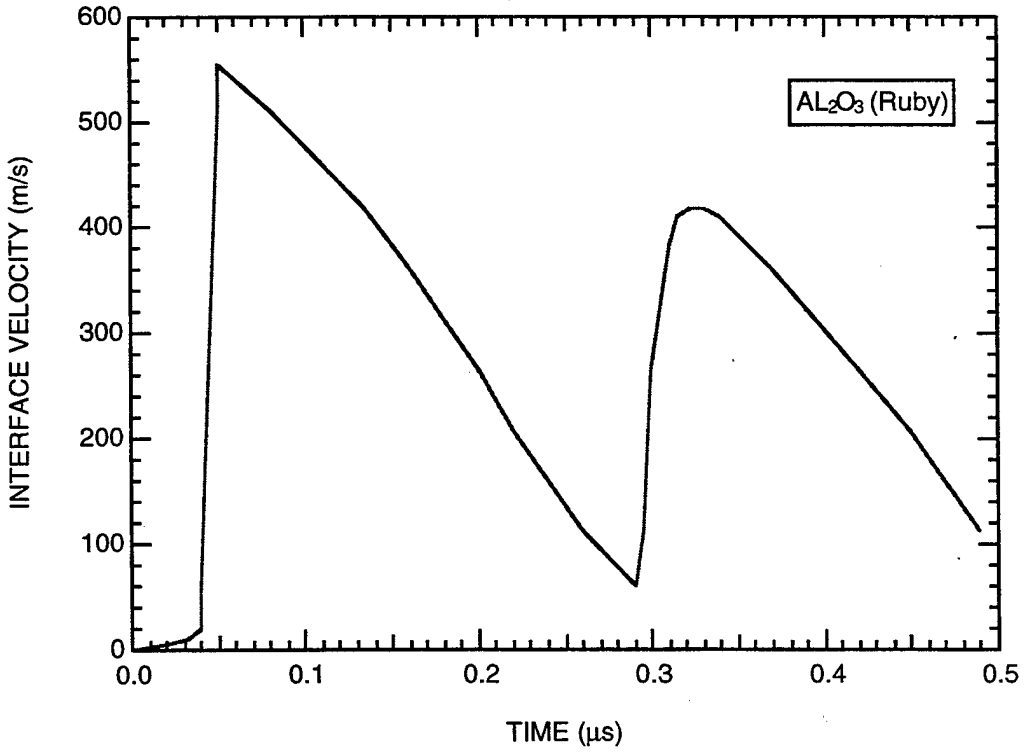
Alumina (Ruby)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs



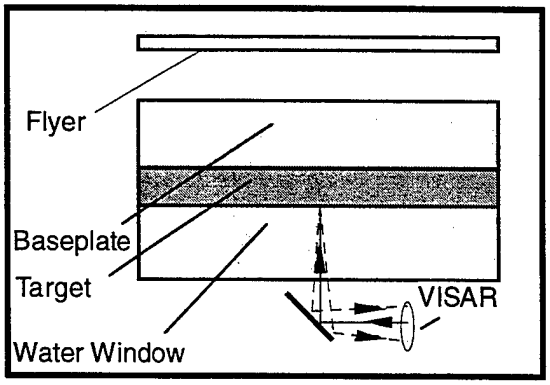
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1250±50 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 4.37 mm
Target: - material - thickness	Alumina (ruby)[1] 2.21 mm
Measurement technique	VISAR (with water window)
Measurement accuracy	±5 m/s
Peak stress Spall strength	13.4 GPa 10.0±0.1 GPa

Reference: Kanel et al. (1993b)

[1] Loaded perpendicular to {1120}.



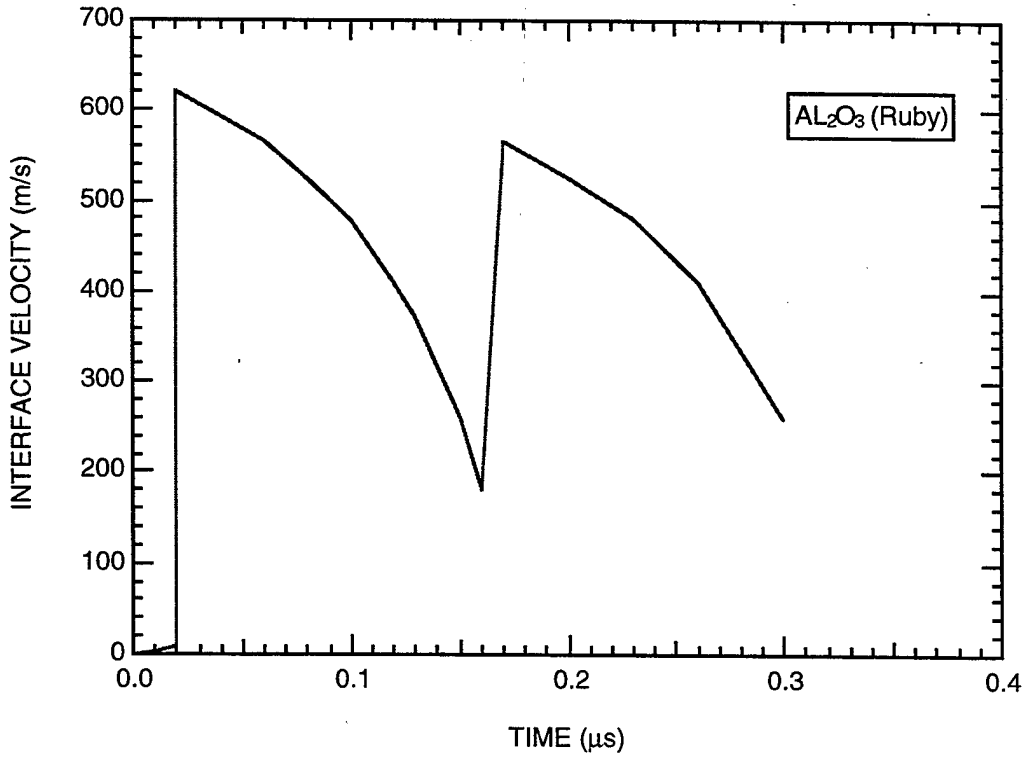
Alumina (Ruby)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs



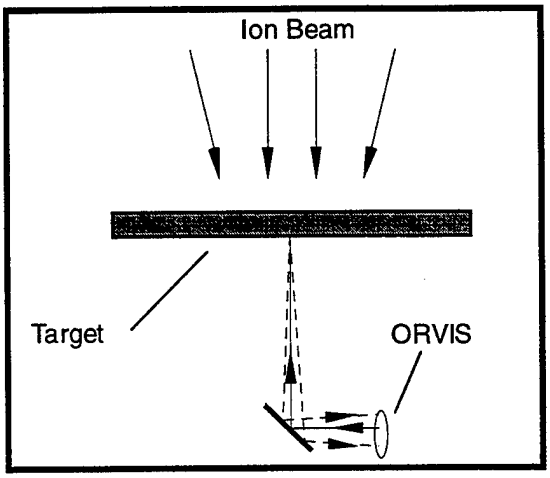
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1250±50 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	Alumina (ruby)[1] 3.65 mm
Measurement technique	VISAR (with water window)
Measurement accuracy	±5 m/s
Peak stress Spall strength	15.0 GPa 8.6±0.1 GPa

Reference: Kanel et al. (1993b)

[1] Loaded perpendicular to {1120}.

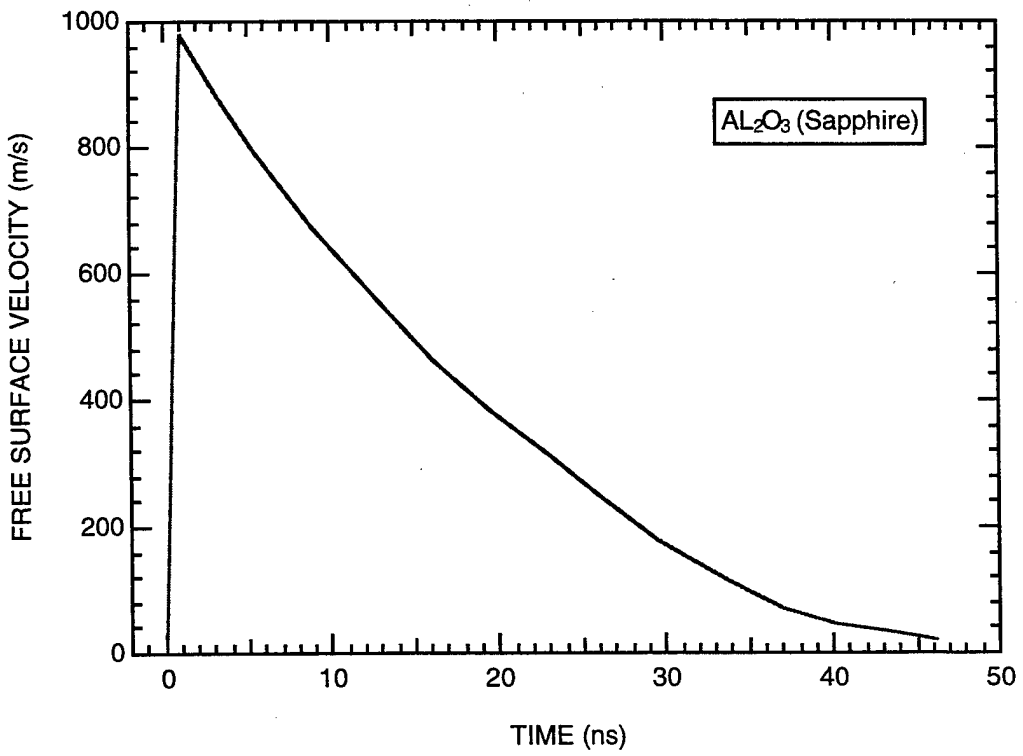


Alumina (z-cut Sapphire)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs

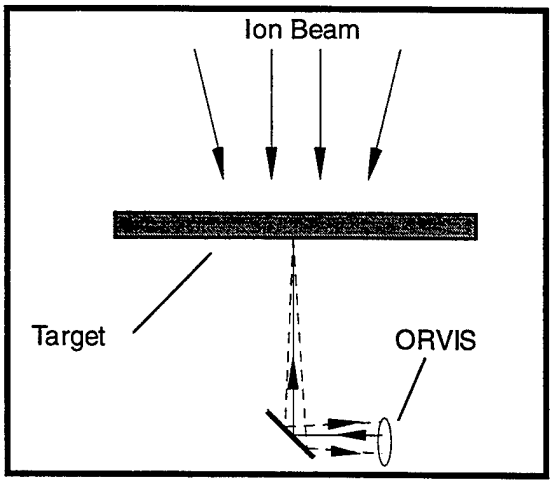


Experiment Summary	
Loading condition	1-D strain
Loading method	Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	5 mm
Target: - material	z-cut Sapphire
- thickness	2.3 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Spall strength	No spall
Peak stress	22.5 GPa
Peak tensile stress	20.5 GPa

Reference: Kanel et al. (1994)

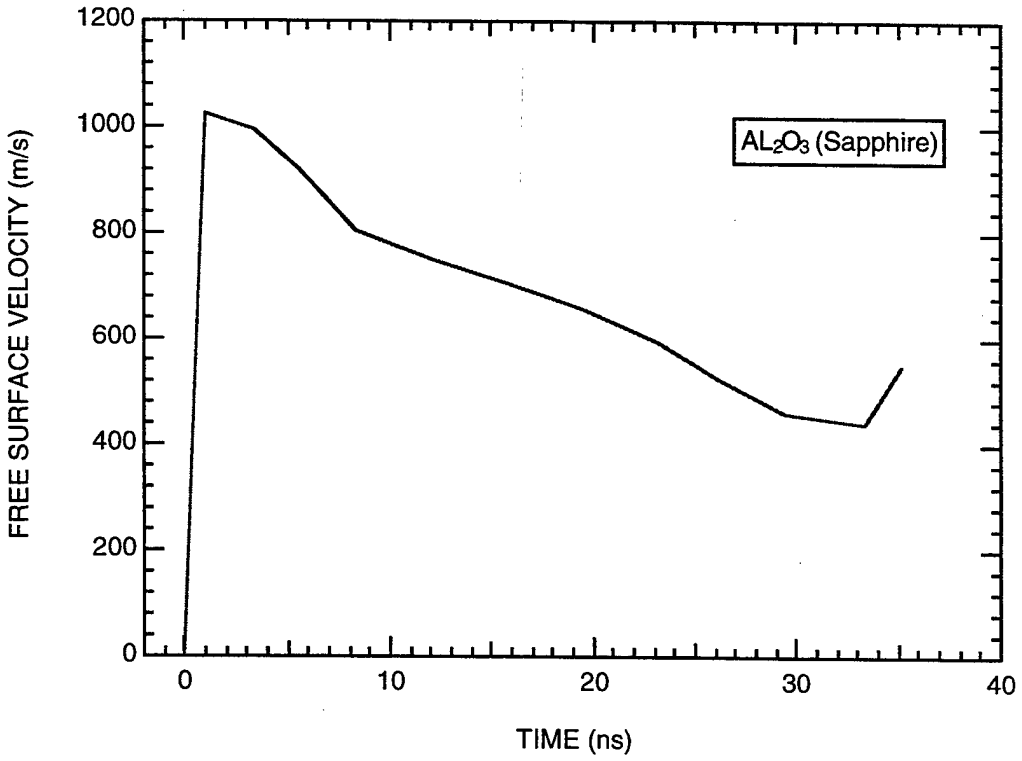


Alumina (z-cut Sapphire)	
Density	3.99 g/cm^3
Bulk sound velocity	8.0 mm/μs
Longitudinal sound velocity	11.2 mm/μs



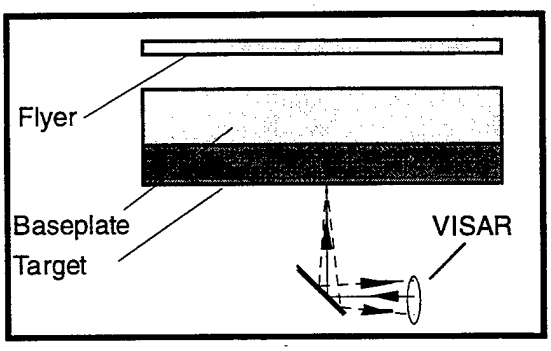
Experiment Summary	
Loading condition Loading method	1-D strain Ion beam
Beam energy density	0.2 TW/cm^2
Beam spot size	5 mm
Target: - material - thickness	z-cut Sapphire 2.3 mm
Measurement technique	ORVIS
Measurement accuracy	±20 m/s
Peak stress Spall strength	24.0 GPa 12.8 Gpa (±6%)

Reference: Kanel et al. (1994)



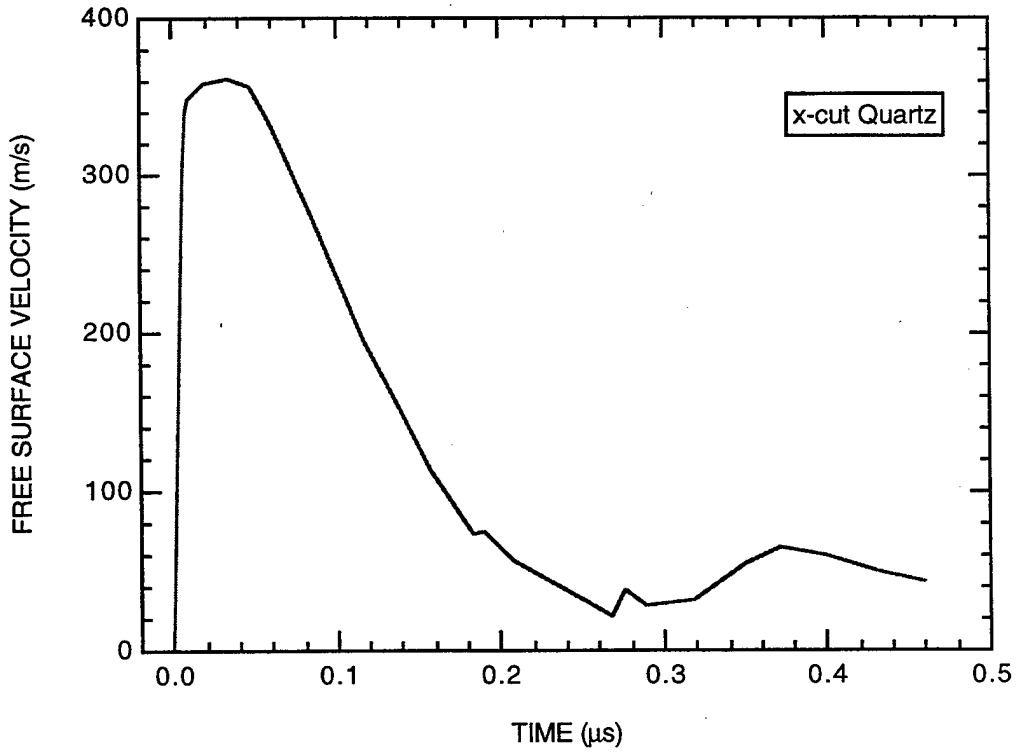
B.33 QUARTZ (X-CUT).

x-cut Quartz	
Density	2.65 g/cm^3
Bulk sound velocity	3.69 mm/μs
Longitudinal sound velocity	5.57 mm/μs

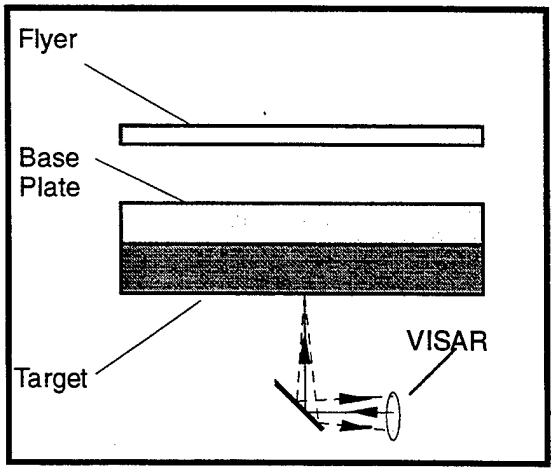


Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.2 mm
Baseplate: - material - thickness	Aluminum 2.9 mm
Target: - material - thickness	x-cut quartz 1.98 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	No spall

Reference: Kanel et al. (1992)

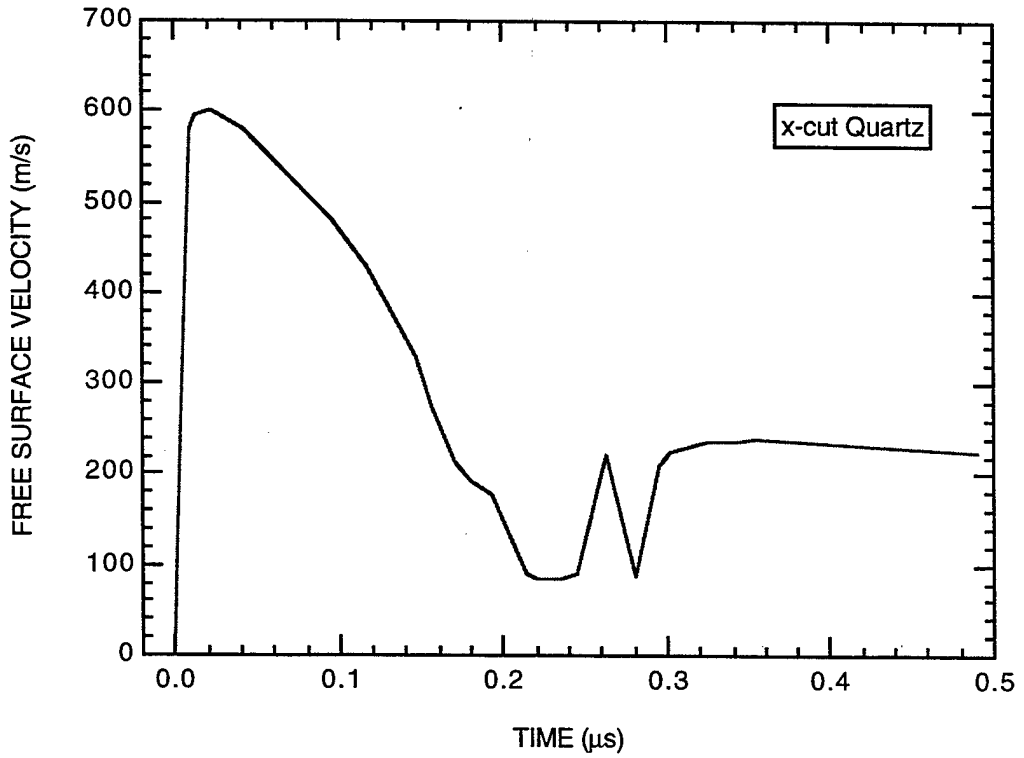


x-cut Quartz	
Density	2.65 g/cm^3
Bulk sound velocity	3.69 mm/μs
Longitudinal sound velocity	5.57 mm/μs



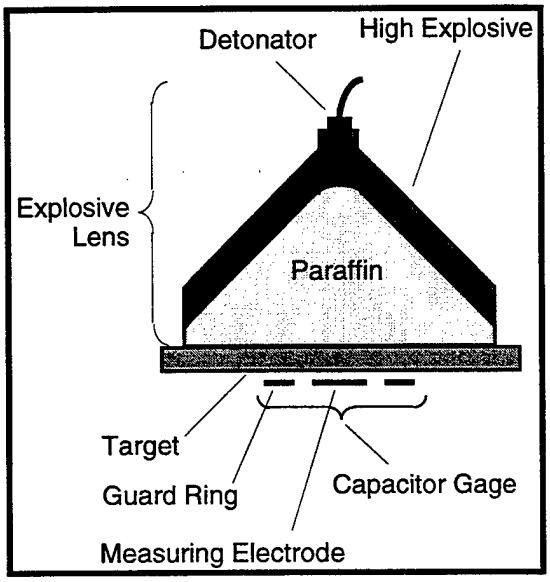
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	660±20 m/s
Flyer plate: - material - thickness	Aluminum 0.4 mm
Baseplate: - material - thickness	Aluminum 2.0 mm
Target: - material - thickness	x-cut quartz 1.98 mm
Measurement technique	VISAR
Measurement accuracy	±5 m/s
Spall strength	4.0±0.03 GPa

Reference: Kanel et al. (1992)



B.34 TITANIUM CARBIDE (WITH NICKEL BINDER).

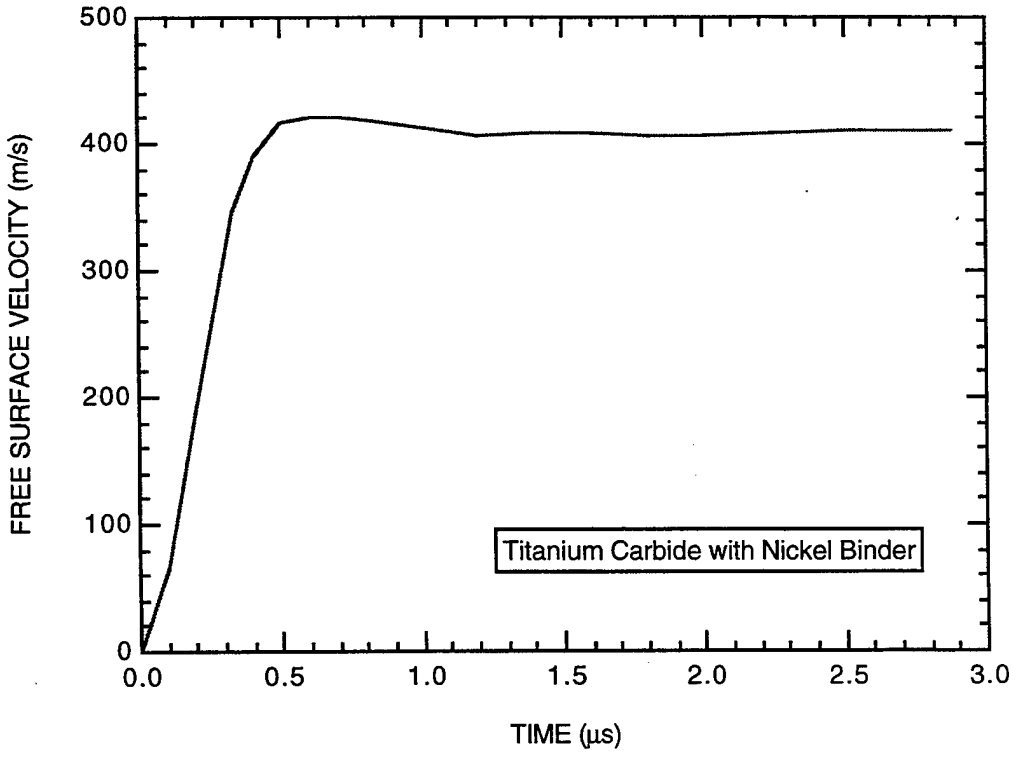
Titanium Carbide With Nickel Binder	
Density	5.28 g/cm^3
Bulk sound velocity	7.0 mm/μs
Longitudinal sound velocity	9.15 mm/μs
Porosity	0.5% - 1.0%



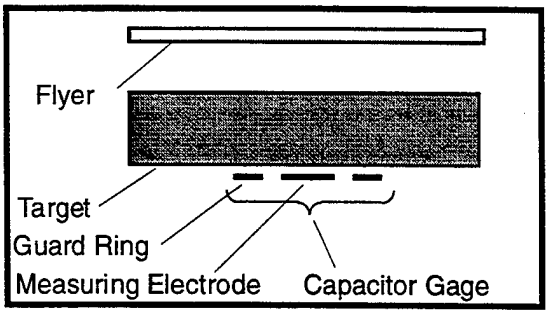
Experiment Summary	
Loading condition Loading method	1-D strain In-contact explosives
Target: - material - thickness	TiC ceramic[1] 10.3 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength	0.35±0.05 GPa

Reference: Kanel and Pityulin (1985)

[1] Titanium carbide (84.5% by weight) with nickel binder.



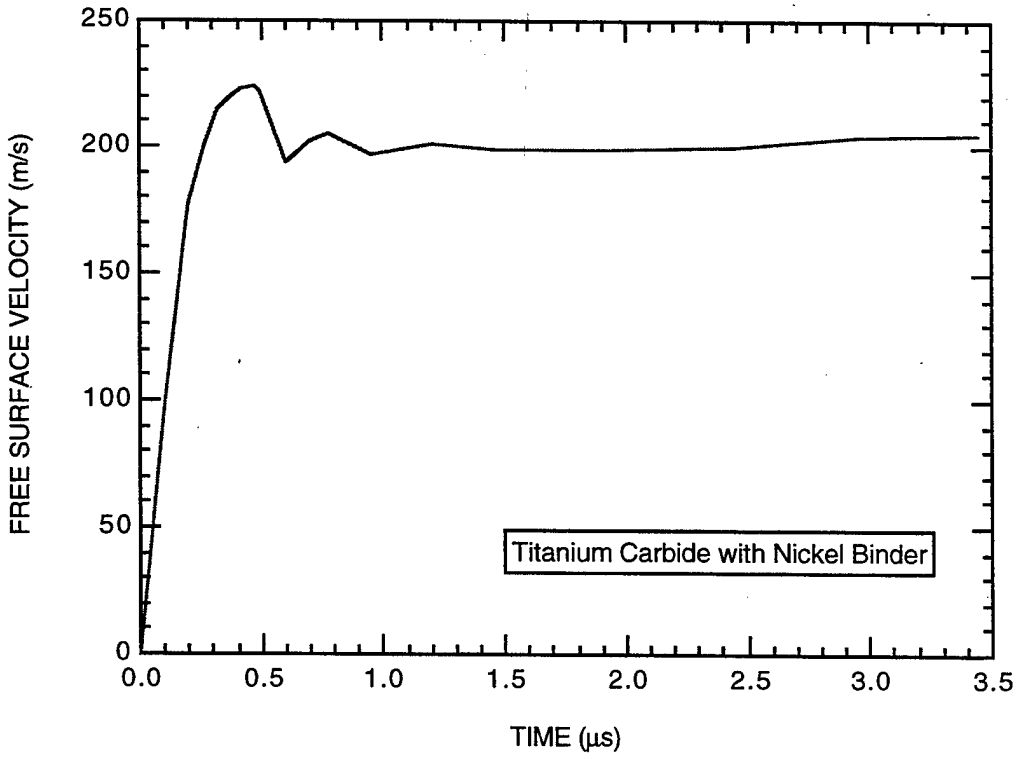
Titanium Carbide With Nickel Binder	
Density	5.28 g/cm^3
Bulk sound velocity	7.0 mm/μs
Longitudinal sound velocity	9.15 mm/μs
Porosity	0.5% - 1.0%



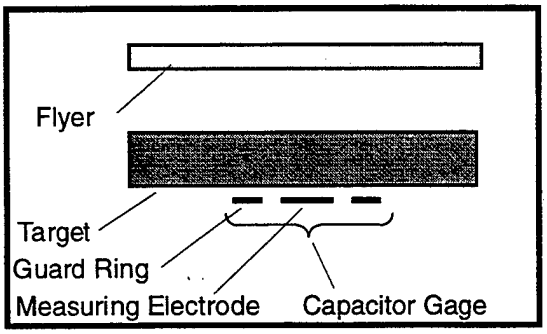
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	450±20 m/s
Flyer plate: - material - thickness	Aluminum 2.00 mm
Target: - material - thickness	TiC ceramic[1] 10.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength Spall thickness	0.5±0.05 GPa Not determined

Reference: Kanel and Pityulin (1985)

[1] Titanium carbide (84.5% by weight) with nickel binder.



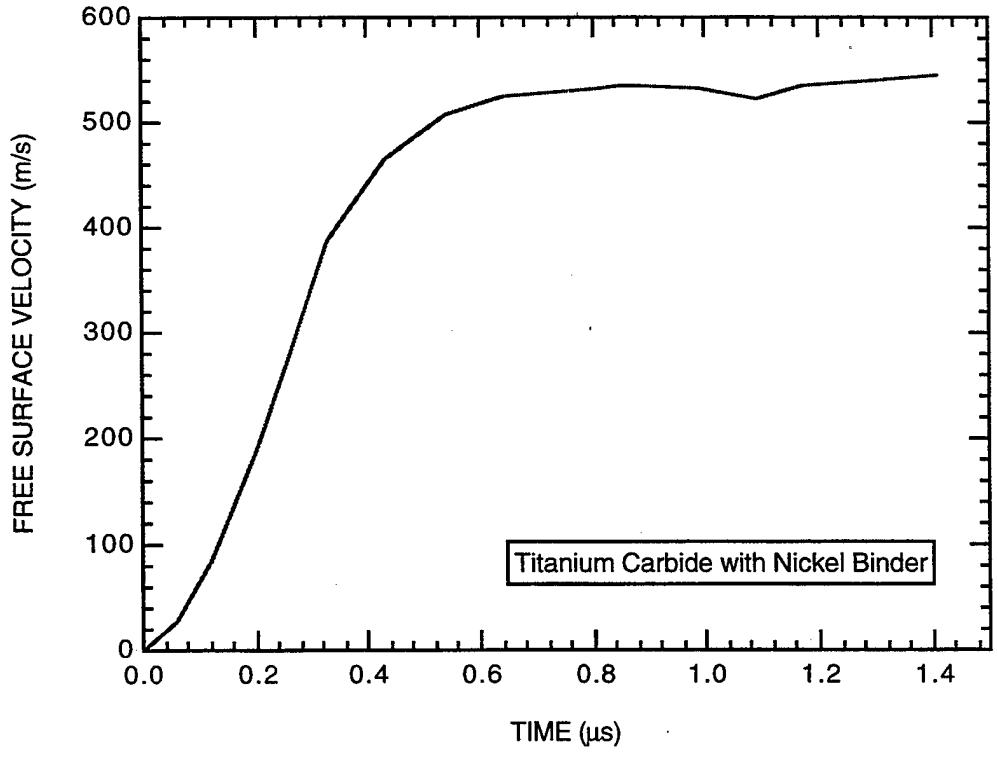
Titanium Carbide With Nickel Binder	
Density	5.28 g/cm^3
Bulk sound velocity	7.0 mm/μs
Longitudinal sound velocity	9.15 mm/μs
Porosity	0.5% - 1.0%



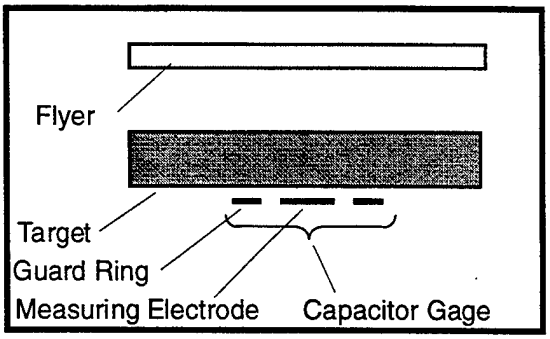
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1050±50 m/s
Flyer plate: - material - thickness	Aluminum 7.00 mm
Target: - material - thickness	TiC ceramic[1] 11.9 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength	No spall

Reference: Kanel and Pityulin (1985)

[1] Titanium carbide (84.5% by weight) with nickel binder.



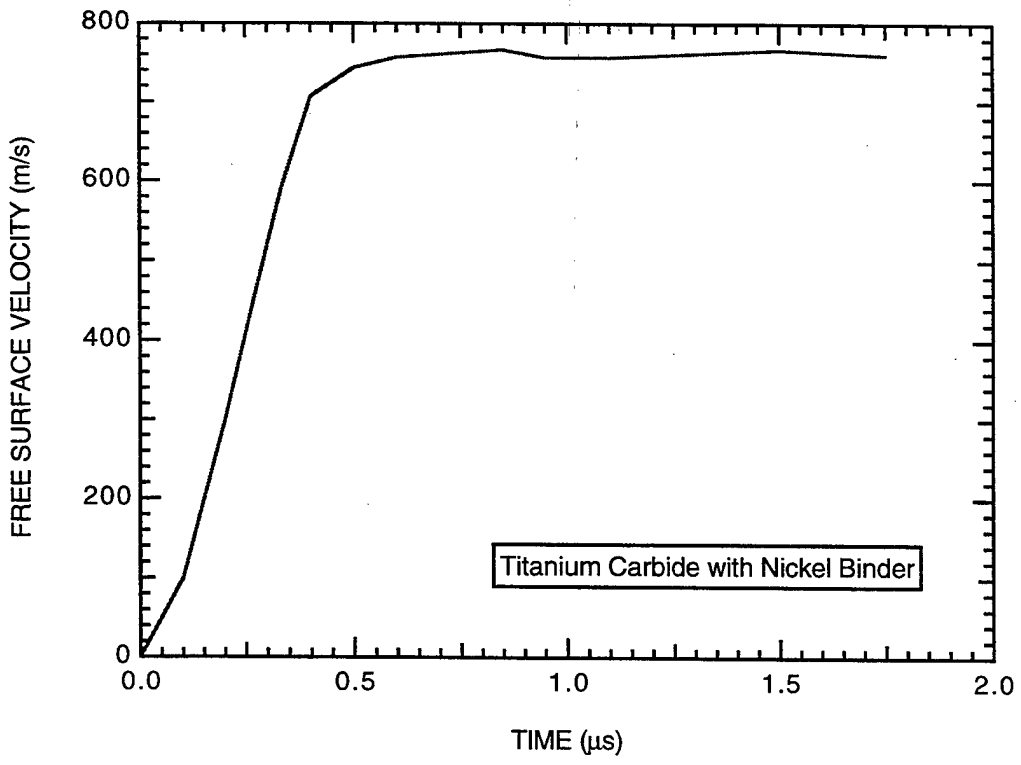
Titanium Carbide With Nickel Binder	
Density	5.28 g/cm^3
Bulk sound velocity	7.0 mm/μs
Longitudinal sound velocity	9.15 mm/μs
Porosity	0.5% - 1.0%



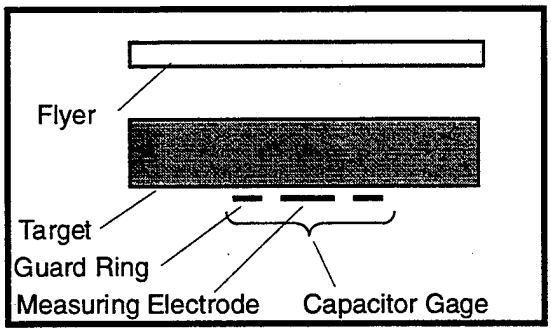
Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1500±50 m/s
Flyer plate: - material - thickness	Aluminum 4.00 mm
Target: - material - thickness	TiC ceramic[1] 10.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	4%
Spall strength	No spall

Reference: Kanel and Pityulin (1985)

[1] Titanium carbide (84.5% by weight) with nickel binder.



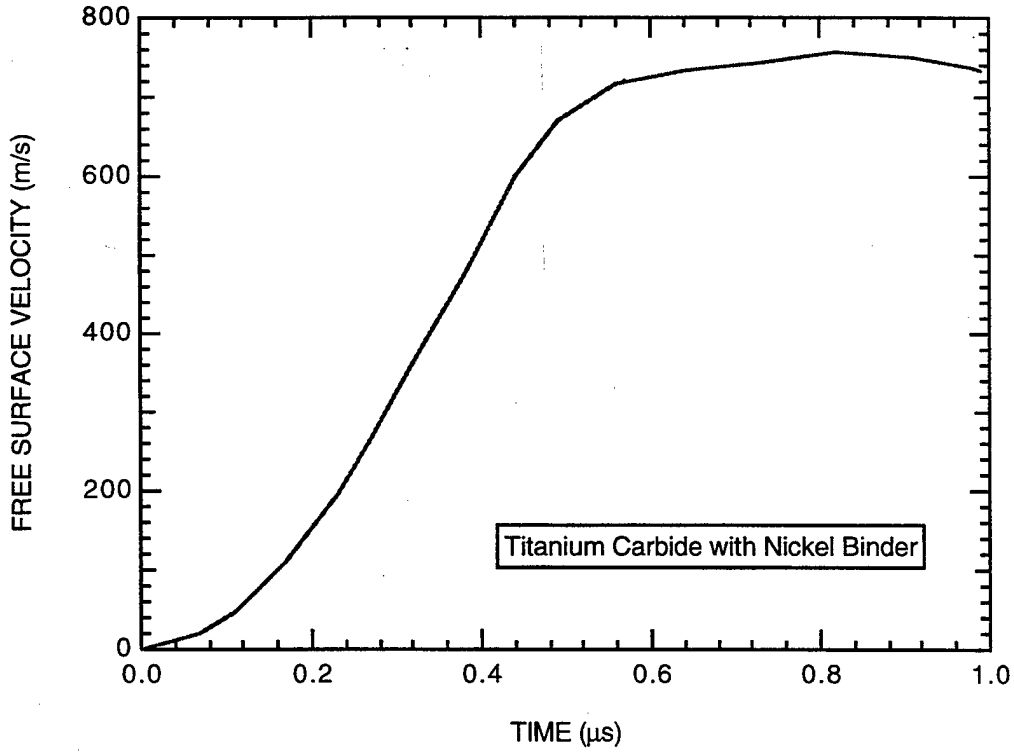
Titanium Carbide With Nickel Binder	
Density	5.28 g/cm^3
Bulk sound velocity	7.0 mm/μs
Longitudinal sound velocity	9.15 mm/μs
Porosity	0.5% - 1.0%



Experiment Summary	
Loading condition Loading method	1-D strain Explosively launched flyer plate
Impact velocity	1500±50 m/s
Flyer plate: - material - thickness	Aluminum 4.0 mm
Target: - material - thickness	TiC ceramic[1] 12.0 mm
Measurement technique Electrode diameter	Capacitor gage 20 mm
Measurement accuracy	±4%
Spall strength	No spall

Reference: Kanel and Pityulin (1985)

[1] Titanium carbide (84.5% by weight) with nickel binder.



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